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Golder Associates

REPORT TO CANMET

PRELIMINARY FIELD TRIALS
TO DETECT M[illegible]SEISMIC ACTIVITY
IN LINGAN COLLIERY
SYDNEY COALFIELD
CAPE BRETON, NOVA SCOTIA
<PERD>

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EXECUTIVE SUMMARY

Golder Associates Ltd. was retained by the Department of Supply and Services Canada on behalf of the Energy, Mines and Resourses Canada's Cape Breton Coal Research Laboratory under contract No. 23440-1-9096 to carry out preliminary field trials to detect microseismic activity around roadway driveage operations at the Cape Breton Development Corporation's Lingan Colliery in the Sydney Coalfield. The driveages of the Lingan Colliery were approaching similar depths to the No. 26 Colliery which had experienced several violent sandstone/gas outbursts during blasting (shotfiring) which had occurred when mining had approached within 2.7 m of a sandstone erosion channel at depths between 700 and 800m. This work was designed to investigate the possibility that sandstone/gas outbursts could occur (in the absence of blasting) through a mechanism resulting from microseismic activity and/or acoustic emission.

Field trials were carried out in an attempt to determine, using relatively simple instruments, whether microseismic activity or acoustic emissions occurred spontaneously or as a result of blasting and roadheader advance at Lingan. A Roctest Geo-Monitor Model MS3 portable geophone and monitor was employed to establish whether dynamic rock failure (which could be a triggering mechanisn for gas outbursts) takes place in the rock at the Lingan faces during the advance of the faces by roadheader. A BMX blast monitor was used to record the characteristic ground motion during and after several blasts including "brushing" blasts and up-dip development blasting in an attempt to detect any microseismic activity that may be triggered as a result of the blasting.

No indications of microseismic activity at the time of face advance, either by blasting or by roadheader mining under conventional geological conditions, were obtained during all of the tests that were done. No burst-prone sandstone was encountered during the course of the project therefore no firm conclusions can be drawn about the behaviour of the burst-prone sandstone.

The MS3 unit was found to be an unsuitable device for any formal long-term monitoring, however it does have a use as an ad hoc listening device. The BMX monitor performed well, but was limited to short time periods of monitoring (ie. six seconds after a blast). It is suggested that a slightly more sophisticated recording device that could provide long-term records of microseismic activity would be necessary to collect data from which meaningful conclusions about the burst-prone nature of the different strata at Lingan could be drawn. A suitable device could be a small microseismic system which is able to operate without supervision and automatically records and locates seismic events and provides long-term records which can be examined to identify trends, such as increases in activity on advance through sandstone channels.

SOMMAIRE EXECUTIVE

Approvisionnement et Services Canada a retenu les services de Golder Associés Ltée au nom du Laboratoire de Recherches sur le Charbon de Cap Breton d'Énergie, Mines et Ressources Canada (contrat no 23440-1-9096) pour réaliser des essais préliminaires d'écoute microséismique dans des galeries de la mine Lingan Colliery appartenant à la Société de Développement du Cap Breton (région charbonnière de Sydney). Les galeries de la mine Lingan Colliery atteignaient la même profondeur que les galeries de la mine No. 26 Colliery qui a subi plusieurs coups de toit (sandstone/gas outbursts) lors de dynamitages. Ces coups de toit se produisaient lorsque les galeries atteignaient une profondeur de 700 à 800 mètres et se situaient à moins de 2.7 m de formations de grès (sandstone erosion channel). Le but de ce travail était de vérifier la possibilité que les coups de toit puissent se produire en l'absence de dynamitage suivant un mécanisme résultant d'activités microséismiques et/ou d'émissions acoustiques.

Des essais ont été entrepris à la mine Lingan afin de tenter de déterminer à l'aide d'instruments relativement simples si une activité microséismique ou des émissions acoustiques se produisent spontanément ou si elles sont le résultat de dynamitage ou encore le résultat due percement des galeries à l'aide d'une machine du type "roadheader". Un appareil portatif Geo-Monitor de Roctest (Modèle MS-3) a été utilisé pour établir si une rupture dynamique des roches prend place dans les faces des galeries de la mine Lingan lors du creusement des galeries à l'aide de machines "roadheader". Un appareil d'enregistrement des vibrations de sautage BMX a été utilisé pour enregistrer les vibrations caractéristiques du terrain pendant et aprés plusieurs sautages (dont des "brushing blasts") afin de détecter de l'activité microséismique qui pourrait avoir résulté des sautages.

Aucune indication d'activité microséismique au moment de l'avance des galeries n'a été obtenue au cours de tous les essais qui ont été effectués, tant lors des sautages que lors du creusement avec le roadheader (dans les conditions géologiques habituelles). Aucun grès sujet au coup de charge n'a été rencontré au cours du projet et par conséquent aucune conclusion ferme ne peu être tirée au sujet du comportement du grés.

Il a été constaté que l'appareil MS-3 était inadéquat pour toutes surveillances à long terme, toutefois cet appareil a une utilité en tant qu'appareil d'écoute "ad hoc". L'appareil BMX a bien performé, mais sa période d'enregistrement se limite à une courte période de temps (i.e. six secondes après un sautage). Il est suggéré qu'un appareil d'enregistrement un peu plus sophistiqué, pouvant effectuer une surveillance à long terme de l'activité microséismique, serait nécessaire pour recueillir une information à partir de laquelle des conclusions signifactives pourraient être atteintes au sujet de la nature susceptible au coup de toit des différentes strates retrouvées à la mine Lingan. Un appareil adéquat pourrait être un petit système d'écoute microséismique qui pourrait être laissé sans surveillance et enregistrerait automatiquement les microséismes et en calculerait la position et fournirait un enregistrement à long terme qui pourrait être examiné pour identifier des tendances, comme une augmentation de l'activité lors de l'avancement dans les canaux de grès.

TABLE OF CONTENTS

Page

Executive Summary i

Sommaire Executive ii

1. INTRODUCTION 1

2. BACKGROUND 2

3. OBJECTIVES 5

4. FIELD TRIALS 6

    4.1 Roctest Geo-Monitor Model MS3 6

        4.1.1 Description of device 6

        4.1.2 Objectives and Monitoring Procedure 6

        4.1.3 Results obtained 8

    4.2 BMX Blast Monitor 10

        4.2.1 Description of device 10

        4.2.2 Objectives and Monitoring Procedure 10

        4.2.3 Results 11

        4.2.4 Peak particle velocity decay law scaling 14

        4.2.5 Comparison between shotfiring and roadheader impacts 14

5. SUMMARY 16

5.1 Use of the MS3 to measure acoustic emissions during mining 16

5.2 The effects of brushing blasts and development blasts 17

5.3 The effects of roadheader cutting 17

6. CONCLUSIONS 18

7. SUGGESTION FOR FUTURE WORK 19

FIGURES 4.1.1. to 4.2.6

TABLE 4.1 Frequency Ranges for Acoustic Emission Readings

APPENDICES A to G

LIST OF FIGURES

Figure 4.1.1 Roctest Geo-Monitor MS3, Filtration Curves
Figure 4.2.1 Lingan Colliery: Typical Brushing Blast Layout 12 East Top Level
Figure 4.2.2 Lingan Colliery: Debris after Brushing Blast 12 East Top Level
Figure 4.2.3 Lingan Colliery: BMX Blast Monitor
Figure 4.2.4 Lingan Colliery: Using the BMX Blast Computer
Figure 4.2.5 Lingan Colliery: Triaxial Geophone Station in Vertical Borehole
Figure 4.2.6 Lingan BMX Tests, Peak Particle Velocity vs. Distance

LIST OF APPENDICES

Appendix A Statement of Work for Preliminary Field Trials to Detect Microseismic Activity in Lingan Colliery
Appendix B Technical Details: Roctest Geo-Monitor MS3
Appendix C Results from Roctest Geo-Monitor MS3
Appendix D Technical Details: BMX Blast Monitor
Appendix E Results from BMX Blast Monitor
Appendix F Exemption Order for use of the RocTest MS-3 and BMX Blast Monitor Underground at Lingan
Appendix G Shotfiring Procedures for use when Advancing through a Sandstone Channel

1. INTRODUCTION

As a result of a request from the Department of Supply and Services Canada (DSS) on behalf of Energy, Mines and Resources Canada's Cape Breton Coal Research Laboratory (CBCRL), Golder Associates Ltd. prepared a proposal to carry out preliminary field trials to detect microseismic activity around roadway driveage operations at the Cape Breton Development Corporation (CBDC)'s Lingan Colliery in the Sydney Coalfield. This work followed from previous studies arising from the sandstone/gas outbursts which occurred at the No. 26 Colliery in the Sydney Coalfield before the No. 26 Colliery was closed by a fire in 1984. Since the advancing roadways at the Lingan Colliery were near to and at comparable depth to the outburst-prone driveages at the No. 26 Colliery, this work was designed to investigate the possibility that outbursts could occur (in the absence of blasting) through a mechanism resulting from microseismic activity and/or acoustic emission (referred to in this report as seismo-acoustic emission).

The establishment of the No. 13 East Longwall at Lingan also provided the last remaining opportunity to measure these effects, since a decision had been taken early in 1991 by CBDC that this would be the last longwall established in the Lingan Colliery. Also, these driveages were at the greatest risk from potential outburst events because of their proximity to the No. 26 Colliery. This meant that the driveages were at comparable depth to those at No. 26 and also that the local geology was similar, increasing the chance that an appropriate sandstone channel would be encountered. This situation resulted in some urgency since the trial would be the last opportunity to obtain the relevant information and also, from a safety viewpoint, CBCRL considered it prudent to have appropriate monitoring devices on hand at the colliery in the event that a sandstone channel was encountered.

It was originally intended that personnel from CBCRL and from CBDC would undergo training in the use of the equipment and assist in the underground trials (see Appendix A). However, reorganizations took place at CBDC during July and August 1991. The result of these reorganizations was that no CBDC staff were available to participate in the monitoring or assist in the underground trials. The trials were therefore carried out with the assistance of personnel of CBCRL alone, whose additional efforts are acknowledged with thanks.

2. BACKGROUND

The No. 26 Colliery in Glace Bay, Nova Scotia experienced several violent sandstone-gas outbursts prior to the colliery's closure in April 1984. These events occurred in the presence of a sandstone erosion channel in situations when this channel was encountered within 2.7 m of the top of the coal seam. In addition, all of the No. 26 Colliery outburst events occurred during blasting (shotfiring).

The most significant difference between the Lingan and No. 26 Collieries is the fact that development in the Lingan Colliery is done using roadheaders whereas drill and blast methods were used in the No. 26 Colliery. A model developed for the initiation of the outbursts at the No. 26 Colliery (GAL Report No. 861-1290) postulated that the blasting had the effect of rapidly reducing the confinement of the burst prone material. This, in turn, mobilized the gas pressure gradient since the stress change which occurs during blasting occurs faster than the gas pressure can change to accommodate it.

Stress measurements done during February 1991 at the Lingan Colliery indicated the existence of an anisotropic virgin stress distribution (with higher stress in the East-West direction), in contrast to the isotropic stress distribution previously measured at the No. 26 Colliery. Because of this, the levels and deeps at Lingan are subject to different stresses, and it was therefore inferred that they are exposed to different levels of outburst risk. On the basis of these stresses, the conclusion was reached that outbursts are likely at the Lingan Colliery if the appropriate geometry, sandstone and gas pressure is encountered and that outbursts are more likely in the deeps than in the levels. Further, the chance of encountering outburst-prone sandstone channels increases as roadways such as the 13 East bottom level advance in an easterly direction, towards the No. 26 Colliery.

Several other factors were also identified as having a bearing on the occurrence of coal/gas and sandstone/gas outbursts. These factors are reviewed briefly here with particular emphasis on the Lingan Colliery.

- **Stresses in the rock**
  It was proposed (GAL Report 861-1290) that the sudden change from a triaxial stress state to a biaxial stress state in the rock adjacent to the mine opening is responsible for creating the conditions conducive to the initiation of the sandstone/gas outburst event.

- **Mechanical properties of the rock**
  The sandstone responsible for the outburst events in the Sydney coalfield is porous and is able to retain significant quantities of gas under pressure, yet it is relatively impermeable. This impermeability is apparently a necessary characteristic for outburst-prone sandstone; without it the gas pressure would be able to dissipate rapidly near the mining openings. In addition, the sandstone appears to be brittle enough to fail with the formation of indirect tension or extension fractures under the appropriate conditions.

The GAL 841-1287 Report provided details of the uniaxial, triaxial, direct tensile and Brazilian tensile strengths of the Lingan sandstone.

- **Core discing**
  Experience in the Sydney coalfield has indicated that core discing is a good indication of likely outburst conditions. Similar observations have been made in other coalfields, although there is no generally accepted explanation of why this should be an indicator of bursting conditions, except in sofar as the phenomenon is an indicator of high stress.

- **Pore gas pressure and gradients**
  Several unsuccessful attempts have been made to determine the in-situ gas pressure in the outburst-prone sandstone. The best estimate of the virgin pore gas pressure would appear to be about 8.5 MPa at the currently advancing faces at Lingan. Since any gas which is present under pressure in a sandstone channel will attempt to permeate into the mining openings, a flow pattern will develop. This flow pattern will set up gradients of gas pressure which vary from virgin gas pressure remote from the mine opening, to atmospheric pressure at the opening boundary. Because of the relative impermeability of the sandstone, these gradients are likely to be high. This means that only a few metres into the sandstone, the gas pressure will be the full virgin gas pressure. As the mine opening is advanced, a new excavation surface is created in essentially undrained sandstone, with high gas pressures present in the rock at the new face. This will result in almost infinite gas pressure gradients, which, together with the stress in the rock, could play a role in the outburst mechanism.

- **Hydraulic properties of the sandstone**
  Because the hydraulic conductivity of the outburst-prone sandstone is so low, it is difficult to measure. A gas permeability test was previously carried out (using the procedure outlined in GAL Report 841-1287), at a pressure of 7.1 MPa. This test yielded a value of roughly 3×10^{-6} cm/s for the gas permeability, within the range expected for outburst-prone sandstone.

The GAL 911-1700 investigation also indicated that the effect of the blast is really more fundamental than simply to provide an additional (static) tensile stress. The dynamic or quasi-instantaneous creation of the mining opening is probably a more significant contributing factor to the initiation of the sandstone-gas outbursts. This raised the possibility that outbursts could initiate in the absence of the blast trigger if the sandstone is capable of inherent unstable or dynamic failure. If the sandstone is capable of such brittle failure, the stress state in the rock around the roadways is high enough to cause dynamic failure to occur, and the microseismic events which this failure generates could provide the trigger for gas outbursts.

Most mines which are prone to dynamic rock failure (bumps, seismic events, rockbursts, etc) make use of sophisticated microseismic systems to detect and locate microseismic activity. The cost of installing, maintaining and running such a system at Lingan could not easily be justified unless it was known whether microseismic activity takes place. This investigation was therefore initiated in an attempt to determine, using relatively simple instruments, whether microseismic activity or acoustic emissions occurred spontaneously or as a result of blasting and roadheader advance at Lingan.

3. OBJECTIVES

Lingan Colliery has adopted certain procedures to test sandstone channels which are encountered during the advance of the longwall roadways (see Appendix G). These procedures involve making test blasts when thick sandstone channels are encountered in an attempt to identify outburst-prone conditions. One of the primary motivations for carrying out the monitoring trials at the chosen time was to arrange that the monitoring instrumentation was available at Lingan during the advancing of the 12 East and 13 East wall roadways and that suitable personnel were available to use the instrumentation to monitor any test blasts which would have been done if a sandstone channel was encountered. This aim of the trials was accomplished, since the monitoring equipment was on hand at CBCRL and CBCRL personnel were able to use the equipment during the advance of the roadways.

Unfortunately (solely from the viewpoint of the trials) the outburst-prone sandstone was not encountered in appropriate channel widths during the period August 1991 to December 1991, so the "emergency" monitoring of test blasts in sandstone channels was not required.

Further objectives of the investigation were to answer the following questions:

- Is there seismoacoustic activity following the test blasts and is this activity relevant from the point of view of the sandstone-gas outbursts which were experienced at the No. 26 Colliery?
- Is there seismoacoustic activity during and immediately after the roadheader advance and is this activity relevant from the point of view of the sandstone-gas outbursts which were experienced at the No. 26 Colliery?
- What are the characteristics of this seismoacoustic activity and how do they compare to a test blast? Could the seismoacoustic activity provide a trigger for a sandstone-gas outburst?
- What are the implications of the findings on ongoing mining operations.

4. FIELD TRIALS

4.1 Roctest Geo-Monitor Model MS3

This device is the property of CANMET and was obtained by the Cape Breton Coal Research Labs on loan from CANMET's Elliot Lake Laboratory.

4.1.1 Description of device

The MS-3 is essentially a high sensitivity compact portable geophone and amplifier which will amplify and count acoustic 'events' (acoustic noises) in rock or soil. The MS-3 is sensitive to frequencies between 2 Hz and 17 kHz which covers the sub-audible to audible range (humans with good hearing can detect frequencies between 20 Hz and 20 kHz). The MS-3 has an adjustable gain control which will amplify the rock noises, and an adjustable amplitude threshold above which it will record an event. In addition, one of its most useful features is three high-cut and three low-cut filters. These filters can be switched in or out in any high/low combination to tailor a particular bandpass, as shown in Figure 4.1.1. This feature enables one to investigate the characteristic frequencies of the acoustic emission studied. This is essential when investigating the origin of the acoustic emissions studied and/or when deciding on the appropriate sensors to use if installing a microseismic system.

The MS-3 is a simple analogue device, with analogue filtration. No digital signal processing or storage occurs. The device is not designed for use as a permanent installation, but rather as a portable ad-hoc probe. The single sensor is waterproof and designed to be installed in a water or grease filled drill hole to monitor local acoustic emission. Two earphone jacks are provided so that two operators can monitor and discuss the acoustic emission at a particular site. Cumulative event counting and a two-period counter (100 seconds or 10 minutes) are provided so that average event rates can also be monitored. A tape output jack is also provided so that acoustic emission can be recorded for later playback and review.

Since the MS-3 is not intrinsically safe, a letter of consent (Exemption Order 91-6, see Appendix F) was applied for and obtained before the unit was taken underground. This order also imposed certain conditions which were complied with each time the device was used.

4.1.2 Objectives and Monitoring Procedure

The primary objective of the investigation using the MS-3 was to establish whether dynamic rock failure (which could be a triggering mechanism for gas outbursts) takes place in the rock at the Lingan faces during the advance of the faces.

The sensor of the MS-3 was in most tests installed using a grease pack method in a drill-hole at or near to the advancing face of the development. This was done (as recommended by the manufacturer) to ensure that the sensor was shielded from local noise caused by movement of personnel or equipment in the tunnel.

Event rates were determined in the five frequency bands indicated in Table 4.1. and shown in Figure 4.1.1, according to the procedures outlined below.

a. **Determine appropriate amplification level ("trigger level")**
The objective here was to determine how sensitive to make the MS-3. Since the amplification level is a relative one, it is not possible to determine a-priori what this level should be. The correct level is one which eliminates unwanted electrical and mechanical background noise, but is sensitive enough to register any acoustic emission which occurs. The earphone jack on the MS-3 can be used to advantage to decide on an appropriate setting. Using the earphone it is generally possible to identify background noise ("hiss" or "hum" or "white noise" are typical descriptions).

In practice, the "trigger level" dial should be set so that a small number of background noise events (as close to zero as possible) are recorded during a ten minute monitoring period. This trigger level will then be sensitive enough to record any additional events above the background noise which are occurring.

During the establishment of the trigger level, all filters should be in the "NORM" position, so that no filtering occurs. Once the trigger level is established, this setting should be kept constant for the remaining tests - no further adjustment should occur.

b. **Establish background noise level**
Take a suite of readings in the five frequency bands (for durations of (say) ten minutes each) after the mine has been standing for some time with no mining activity, i.e. at the beginning of a new week or after a vacation period during which no mining took place. This "standing time" will allow a maximum of time for stress re-adjustment to occur. The suite of readings will establish how quiet the rock is when in equilibrium. The data can be plotted in histogram form, showing the event rate in each frequency range, or simply as the number of events which occurred during the selected time interval.

c. **Measure acoustic emission during roadheader advance**
The major drawback of measuring acoustic emission during the advance of the

roadheader is that most of the noise measured will be due to the pick impacts and due to mechanical noise as the heavy equipment is moved. A suite of readings (same frequency intervals and time periods) should be taken during roadheader advance after the normal pattern of mining has been established. This will probably not be at the start of a new shift, but should rather be done near the end of the shift, so that new (possibly stressed) rock is being excavated. This suite of readings should also be plotted on the same histogram form as the background readings, and should establish the frequency ranges of acoustic emission characteristic of roadheader operation.

d. **Measure acoustic emission after suspension of mining**

After the roadheader has been in operation for some time, say at the end of a shift, it should be shut down, and a suite of readings should be taken. This suite of readings is intended to measure the way the rock readjusts to the newly-imposed stress state generated by the new opening shape. If the rock adjusts immediately and quasi-statically, then there should be no acoustic emission after the roadheader shuts down. However, if there is some time-dependent or dynamic behaviour of the rock locally, then a series of acoustic emission events should be detected. The rate of occurrence of these events should decay (usually exponentially) with time, and it is therefore important to begin the tests as soon as possible after shutdown. Since the MS-3 is equipped with dual counter time intervals of 1 minute and 10 minutes, it would also be useful to take readings using the 1 minute interval duration for 10 successive minutes so that the decay of activity can be recorded. If sufficient data are obtained it should be possible to determine a time constant for the microseismic events. This will be useful in investigating the volume of rock which is failing around the excavation.

4.1.3 Results obtained

Results of the Geo-Monitor are included in Appendix C. Based on these results the following conclusions can be drawn:

- The Geo-Monitor was found to be extremely sensitive to environmental noise. This means that even using the installation technique described above, the MS3 registered events associated with the movement of personnel and equipment in the mining development. Even persons talking nearby were often recorded as "events". Further, the events recorded were particularly sensitive to the way the sensor was installed and this is believed to have affected the readings taken, in spite of the consistent procedure adopted.

- The results obtained were also very subjective - it was not possible to be consistent between different observers. This means it is not possible to compare suites of readings done at different times by different observers.

- Some faint acoustic emissions (at the level of audibility using the amplifiers on the MS3) were on occasion heard in the level development. These can be described as "pops", "cracks" or "snaps" and were barely discernable above the electrical background noise when the amplifier level was high. However, it was not possible to make recordings of the events since no IS tape recorder was available during the experiments. The noises heard could have been acoustic emission or microseismic activity, but it was not possible to describe them further. The noises were only detected as events when the trigger level was relatively low. The lower the trigger threshold, the more events were recorded.

- Loud noises were recorded in exactly the same way as the smallest noises detected, i.e. every detected noise was recorded as "an event". This is a major disadvantage of the event counter approach.

Overall, the MS3 unit was not found to be useful in the study for the purpose of gathering data for making later quantitative comparisons between different situations. The MS3 unit is useful for "listening" to the rock in the simplest form of this activity. Recordings of number of events are relative only, and depend on the method of sensor installation, the selected amplification level, and the selected trigger levels.

A final conclusion can also be drawn from the MS3 study. It is clear from the above conclusions that no convincing evidence of acoustic emission or microseismic activity was encountered, since all of the above problems would have been experienced in the absence of acoustic emission. If there was real acoustic emission occurring, it would have been heard during quiet monitoring periods. During the MS3 trials, the event counter was triggering on noise; the lower the trigger threshold, the more noise was detected. Simply stated, the rock was too quiet by comparison to the activity taking place nearby for meaningful results to be obtained.

4.2 BMX Blast Monitor

4.2.1 Description of device

The BMX blast monitor is a device which records a time history of ground motion (velocity or acceleration). Usually, blast monitors are used to record ground motion due to the detonation of a nearby explosive charge (see Figures 4.2.1 and 4.2.2). This is done in order to carry out blast diagnostics; interpretation of the sequence and accuracy of the initiation and detonation of the explosive charges. A typical vibration measuring system such as the BMX system consists of four main components (see also Figures 4.2.3 to 4.2.4):

- A three-component orthogonal array of vibration sensors (Geo-Space 20 DX, 8 Hz, 395 Ω vertical and horizontal geophones were used Lingan).
- A cabling system (Belden 8777 shielded three pair).
- An amplification, digitization and storage unit (the BMX unit).
- A Toshiba T1200 portable computer (with BMX software), used to store and interpret the recorded waveforms (Figures 4.2.3 and 4.2.4).

The sensors used at Lingan were in all cases installed in vertically oriented boreholes drilled upward into the roof sandstone immediately above the Lingan seam (Figure 4.2.5). These were orientated in the UP (vertical), E-W (strike horizontal), and N-S (dip horizontal) directions. This arrangement allowed the vertical and two horizontal components of the ground vibration to be measured.

4.2.2 Objectives and Monitoring Procedure

In the project described here, the BMX was used to record the characteristic ground motion during and after several blasts. These blasts were of two different types, namely "brushing" blasts for level development (Figures 4.2.1 and 4.2.2) and up-dip development blasts for the new 13 East wall. In addition, the characteristic ground vibrations induced by the road header were also recorded in order to compare these motions to typical blast signatures. Procedures were similar in all cases:

- The geophone array was cemented into the vertical borehole, located in a convenient position near to the site of the blast.
- All cabling and trigger connections were made.

- The software module on the Toshiba computer was used to enter the required parameters into the BMX unit.

- The trigger wire was trailed to the site of the blast initiator.

- The BMX unit was armed by means of its security key.

- When the blaster had cleared the site for the blast, the trigger wire was manually broken (thus starting the recording sequence) about 0.5 seconds before the blaster initiated the charge.

A total data recording time of 6.5 seconds was chosen at a sampling frequency of 10 kHz. This enabled reasonably high frequencies to be measured, with a reasonably long time window to reveal any microseismic activity initiated by the blast. In practice the blast usually detonated at about 0.5 seconds into the recording window, and the total blast duration of all delays was usually less than 0.5 seconds. This enabled about six seconds of post-blast activity to be recorded.

Initially, amplification levels of 56 mm/s full scale deflection, 28 mm/s full scale deflection and 14 mm/s full scale deflection were selected as trials (Blast Record LING03). From these, a level of 14 mm/s FSD was selected as the most appropriate and this level was used in the remainder of the trials for consistency of the results.

4.2.3 Results

The results of the BMX trials are included as Appendix E. All recorded plots of measured velocities are included, as well as detailed summaries of the key parameters measured and the main findings. The more significant tests carried out with the BMX unit and the findings of these tests are briefly discussed below (equipment test blasts are excluded).

BLAST RECORD: LING03
This test was done in Lingan sandstone above the coal seam during an early morning brushing blast @ 12 East Top Level with the geophone array installed at a distance of 7.9 m from the blast centroid. From the blast record it was not possible to see the individual delay groups. This could be due to scatter of firing times of the caps or some simultaneous detonation could have occurred. The total blast signal duration was slightly longer than the theoretical duration, as would be expected for a blast of this nature. No unusual signals followed the blast. It was concluded that no microseismic activity occurred within the 6 second time window after the blast.

BLAST RECORD: LING05

This recording of a brushing blast was also made in the Lingan sandstone above the coal seam using the same geophone array as the LING03 test (12 East Top Level). It was once again not possible to see the individual delay groups. This could be due to scatter of firing times of the caps or some simultaneous detonation could have occurred. The blast was in all respects similar to the LING03 record. The rock was quiet after the blast. It was concluded that no microseismic activity occurred within the 6 second time window after the blast.

BLAST RECORD: LING06

This record was of an afternoon brushing blast on the 12 East Bottom Level. In this case the delays #1, #2, #3 and #6 were all clearly visible (see Appendix E). It would appear that the blast fired as planned. There was a slight scatter in the groups, especially the early groups. The rock was quiet after the blast and no unusual signals were recorded. It was concluded that no microseismic activity occurred within the 6 second time window after the blast.

BLAST RECORD: 13EB2

This blast was recorded on 13 East Bottom Level. Charges were placed in the Lingan seam and roof sandstone. A slight scatter was evident in each group and some decaying vibrations followed the blast, but no unusual microseismic signals were recorded. The rock was quiet after the blast. It was concluded that no microseismic activity occurred within the 6 second time window after the blast.

BLAST RECORD: 13EB4

This blast, the second shot of an intersection development round, was recorded in the Lingan roof sandstone (the coal shot was missed due to equipment malfunction). A slight scatter was noted within the groups, but very a very clear four group initiation pattern is evident. The rock was quiet after the blast although some slight noise is evident (probably electrical noise). It was concluded that no microseismic activity occurred within the 6 second time window following the blast.

BLAST RECORD: 13EB5

This was the first blast recorded where the shots were fired in the Lingan coal seam and the roof sandstone together. A fair scatter within the groups was noted, but there was probably no overlap. Some decaying vibrations followed the blast, but no unusual microseismic signals were recorded. It was concluded that no microseismic activity occurred within the 6 second time window following the blast.

BLAST RECORD: 13EB6

This record shows a shot fired in the Lingan seam. The recorded vertical signal was unusually small by comparison with similar blasts, probably indicating some decoupling between the blast and the geophone array in a vertical sense, possible due to open bedding planes between the blast and the array. Some scatter was noted within the groups. The initiation pattern was not very clear, but this is partly due to the distance between the array and the blast (25 m). The rock was quiet after the blast with no unusual signals apart from slight electrical noise. It was concluded that no microseismic activity occurred within the 6 second time window after the blast.

BLAST RECORD: 13EB7

This record shows the roof sandstone blast immediately after blast 13EB6. There was a slight scatter within the groups, but a reasonably clear initiation pattern was evident. The group at the #5 delay cap had a very strong signal in the vertical component (no explanation for this could be ascertained). The group at the #6 delay was later than expected. The rock was quiet after the blast and no unusual signals apart from slight electrical noise were recorded. It was concluded that no microseismic activity occurred within the 6 second time window after the blast.

ROADHEADER MINING RECORD: TESTUG05

This record of the Alpine miner cutting the sandstone was made within a distance of 3 m of the cutting head in the Lingan roof sandstone, thus giving a good strong signal. Both the longitudinal and the transverse records showed a good clear signal, characteristic of the cutting action of the Alpine miner. The maximum amplitude component occurred at a frequency of 400 Hz (see Appendix E). This frequency probably represents the likely impact frequency of the individual picks on the cutting head at that particular head rotation speed.

ROADHEADER MINING RECORD: TESTUG07

This record of the Alpine miner cutting the sandstone was made within a distance of 3 m of the cutting head in the Lingan roof sandstone. Both the longitudinal and the transverse records showed a good clear signal, characteristic of the cutting action of the Alpine miner. The maximum amplitude component occurred at a frequency of 250 Hz (see Appendix E). This frequency probably represents the likely impact frequency of the individual picks on the cutting head at that particular head rotation speed.

ROADHEADER MINING RECORD: TESTUG08

In this case the cutter was cutting the Lingan coal seam, hence giving a weak signal. No microseismic activity was evident within the time window of active cutting recorded.

ROADHEADER MINING RECORD: TESTUG09

Once again a weak signal was recorded since the cutter was cutting coal. The signals which were recorded appeared to have their strongest component at frequency of about 16 Hz. No microseismic activity was noted within the time window of active cutting recorded.

ROADHEADER MINING RECORD: TESTUG10

This was the last attempt made to record the action of the cutter during mining of the Lingan coal seam. Again, the strongest component appeared to be recorded with a characteristic frequency of about 20 Hz. No microseismic activity was evident within the time window of active cutting recorded.

4.2.4 Peak particle velocity decay law scaling

The peak particle velocity due to a blast is usually correlated with the distance to the blast and the weight of explosive per delay. This is usually done by means of a "scaled distance" concept. The parameters of these scaled distance laws are site-dependent, since they are influenced by coupling, rock type, confinement and similar properties of the geometry of a particular site. Since the blasts recorded by the BMX in this exercise all had essentially similar charge weights, the ppv was scaled to the distance as shown in Figure 4.2.6. Since the data are sparse, a more sophisticated fitting procedure was not believed to be warranted here. On this basis, the best fitting relationship was found to be the inverse square law:

$$\text{ppv} = 3030/D^2 \quad \ldots \quad 4.1$$

Where:

ppv = Peak particle velocity in mm/s

and

D = Distance to blast in m.

This relationship can be used to determine the likely ppv near typical Lingan brushing and development blasts and can also be used to compare the effects of the roadheader to the effects of the blast in a quantitative fashion.

4.2.5 Comparison between shotfiring and roadheader pick impacts

The BMX records of the pick impacts produced by the Alpine roadheader indicate a maximum ppv at the geophone site of 2.0 mm/s, at a distance of 3.0 m. With reference to Figure 4.2.6, the expected ppv due to a typical Lingan blast at this same distance would be 336 mm/s according to the scaling law derived above, a difference of more than two orders of magnitude. This simple comparison provides some indication of the comparative dynamic difference between the blasts and the pick impacts of the roadheader. This comparison implies that in the absence of some form of dynamic trigger such as microseismic activity (which could occur in sandstone of the appropriate channel widths) outbursts are unlikely to be caused by the roadheader alone.

5. SUMMARY

5.1 Use of the MS3 to measure acoustic emissions during mining

Several difficulties arose in the interpretation of the acoustic emission test data. The monitoring for acoustic emissions was also found to be fairly subjective. Unfortunately the level development was far noisier than was originally anticipated in spite of choosing the quietest shift for the monitoring trials. The events monitored by the MS3 monitor seemed to correlate with activity in the levels such as moving the machines, starting the conveyor, or setting arches.

The MS3 trials were thus unsatisfactory and inconclusive for the following reasons:

- The Geo-Monitor was found to be extremely sensitive to environmental noise associated with the movement of personnel and equipment nearby. The events recorded were also particularly sensitive to the way the sensor was installed, in spite of the consistent installation procedures adopted.

- The results obtained were subjective and it was not possible to compare suites of readings done at different times by different observers.

- Some faint acoustic emissions (described as "pops", "cracks" or "snaps") were heard in the level development. These were barely discernable above the electrical background noise under high amplification. The noises heard could have been acoustic emission or microseismic activity, but they only triggered the recorder when the trigger threshold level was low.

- Loud noises were recorded in exactly the same way as the smallest noises detected, i.e. every detected noise was recorded as "an event". This is a major disadvantage of the event counter approach.

The MS3 unit was not found to be useful in the study for the purpose of gathering data for making later quantitative comparisons between different situations. The MS3 unit was found to be useful for "listening" to the rock only. The event counts were relative only, and depended on the method of sensor installation, the selected amplification level, and the selected trigger levels.

A final conclusion (of a subjective nature) can also be drawn from the MS3 study. It is clear from the results described that no convincing evidence of acoustic emission or microseismic activity was encountered, since all of the above problems would have been experienced in the absence of acoustic emission. If there was real acoustic emission occurring, it would have been heard during quiet monitoring periods. During the MS3 trials, the event counter was triggering on noise; the lower the trigger threshold, the more noise was detected. Simply stated, the rock was too quiet by comparison to the activity taking place nearby for meaningful results to be obtained.

5.2 The effects of brushing blasts and development blasts

Several brushing blasts and development blasts were monitored using geophones (velocity transducers) at distances of between 5 m and 25 m from the blast. Two orthogonal horizontal components and the vertical component of local ground velocity were recorded during the blasts. In the case of the close range records, the peak particle velocity exceeded the instrument's range. However, it was possible to fit a conventional inverse-square curve to the recorded peak particle velocity to derive a local ppv vs. distance relationship for the brushing blasts and development blasts as they were done during the trials. This relationship may be used for prediction or blast design purposes at Lingan and can be refined further by considering the differences in charge weight and rock type. This work was not extended because of time considerations and because it did not form part of the objectives of the study.

From a blast diagnostic viewpoint, in most cases the delay groups of the blast were clearly discernible and no signs of sympathetic detonation or misfires were found.

Most of the recorded blasts were in sandstone, although no sandstone with outburst-prone characteristics was encountered during the trials. In all of the recorded blasts, no unusual signals characteristic of microseismic activity or acoustic emission were noted during the six second recording window after the blasts. The only dynamic activity evident was that due to the blasts themselves.

5.3 The effects of roadheader cutting

Several good records of the noises characteristic of the roadheader cutting coal and sandstone were made. These "seismic events" are due to the picks impacting the rock and breaking small pieces from the face as the advance takes place. The pick impacts occur at a frequency characteristic of the speed of rotation of the cutting head, number and arrangement of picks, etc.

Dominant frequencies of between 250 Hz and 400 Hz were recorded when a strong signal was received while the head was cutting sandstone. In other cases, where weaker signals were recorded while the head was cutting looser coal, lower frequency noise was recorded between 10 Hz and 20 Hz. This probably represents the speed of rotation of the head.

In no cases were signals characteristic of microseismic events recorded during the roadheader cutting.

6. CONCLUSIONS

The primary objectives of this investigation were stated in terms of several questions which the monitoring exercise was intended to answer:

- Is there seismoacoustic activity following the test blasts and is this activity relevant from the point of view of the sandstone-gas outbursts which were experienced at the No. 26 Colliery?

In all blasts recorded (most of which were in sandstone) no unusual signals characteristic of microseismic activity or acoustic emission were noted during the six second recording window after the blasts. The only dynamic activity evident was that due to the blasts themselves.

- Is there seismoacoustic activity during and immediately after the roadheader advance and is this activity relevant from the point of view of the sandstone-gas outbursts which were experienced at the No. 26 Colliery?

Good records of the noises characteristic of the roadheader cutting both coal and sandstone were made. Dominant frequencies of between 250 Hz and 400 Hz were recorded when a strong signal was received while the head was cutting sandstone, while in other cases, where weaker signals were recorded while the head was cutting looser coal, lower frequency noise was recorded between 10 Hz and 20 Hz. In no cases were signals characteristic of microseismic events recorded during the roadheader cutting.

- What are the implications of the findings on ongoing mining operations.

The most disappointing aspect of the investigation was that no burst-prone sandstone in appropriate channel widths was encountered during the course of the project. This meant that, although a full suite of recordings was done under several different conditions, no firm conclusions can be drawn about the behaviour of the burst-prone sandstone, since none was encountered. During all of the tests which were done, no indications of microseismic activity at the time of face advance either by blasting or by roadheader mining under conventional geological conditions were obtained. Unfortunately however, the investigation could not draw meaningful conclusions about the behaviour during the unusual conditions which would be presented when mining through the outburst-prone sandstone.

7. SUGGESTION FOR FURTHER WORK

The principal difficulty of the investigation was the limited amount of data available. Each record (both with the BMX and the MS3) had to be made by taking the equipment underground by hand and recording the activities taking place. In the case of the MS3 this also meant that it was not possible to make comparisons between readings made at different times, mainly because of the sensitivity of the instrument to method of installation. The results can be further criticized because any seismic events which occurred outside the monitoring trials would have been missed.

The MS3 was found to be an unsuitable device for any formal long-term monitoring, although it does have a use as an ad hoc listening device. The BMX worked well, but only recorded fairly short time periods (usually six seconds after the blast).

These difficulties can be resolved by making use of a slightly more sophisticated recording device which is semi-permanently installed near to an area where outburst events are anticipated. A suitable device could be a small microseismic system which is able to operate without supervision and automatically records and locates seismic events and provides long-term records which can be examined to identify trends, for example increases in activity on advance through sandstone channels. Consistent long-term records of this type of information would be necessary before meaningful conclusions about the burst-prone nature of the different strata at Lingan could be drawn.

GOLDER ASSOCIATES LTD.

for R.K. Brummer, P.Eng.

C.M. Steed, P. Eng.

LICENSED PROFESSIONAL ENGINEER
C. M. STEED
PROVINCE OF ONTARIO

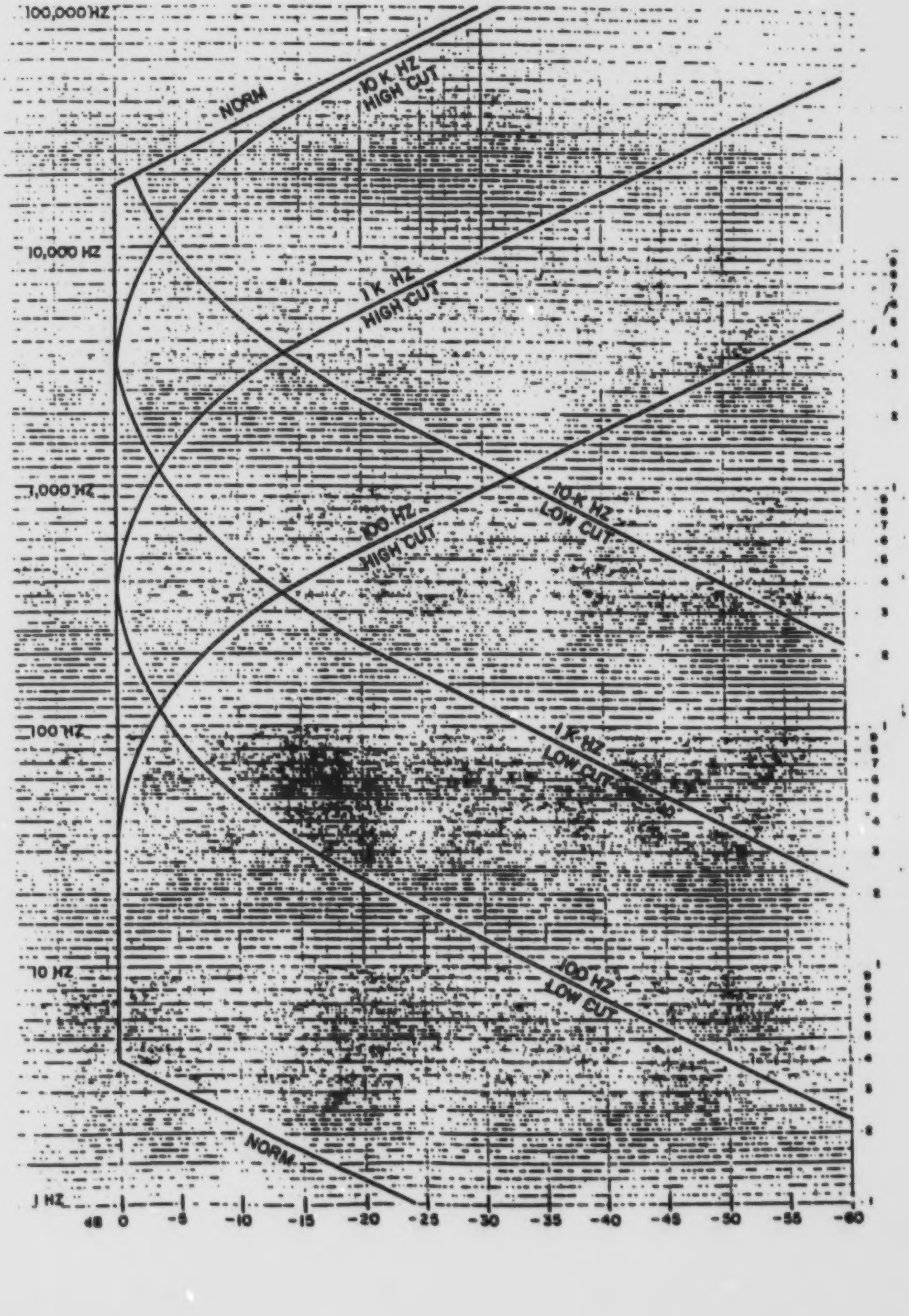
RKB/CMS/rkb

TABLE 4.1
Frequency ranges for acoustic emission readings

Frequency Band	Low Cut Filter	High Cut Filter	Remarks
1	NORM	NORM	Wide
2	NORM	100 Hz	Low
3	100 Hz	1 kHz	Low-Med
4	1 kHz	10 kHz	High-Med
5	10 kHz	NORM	High

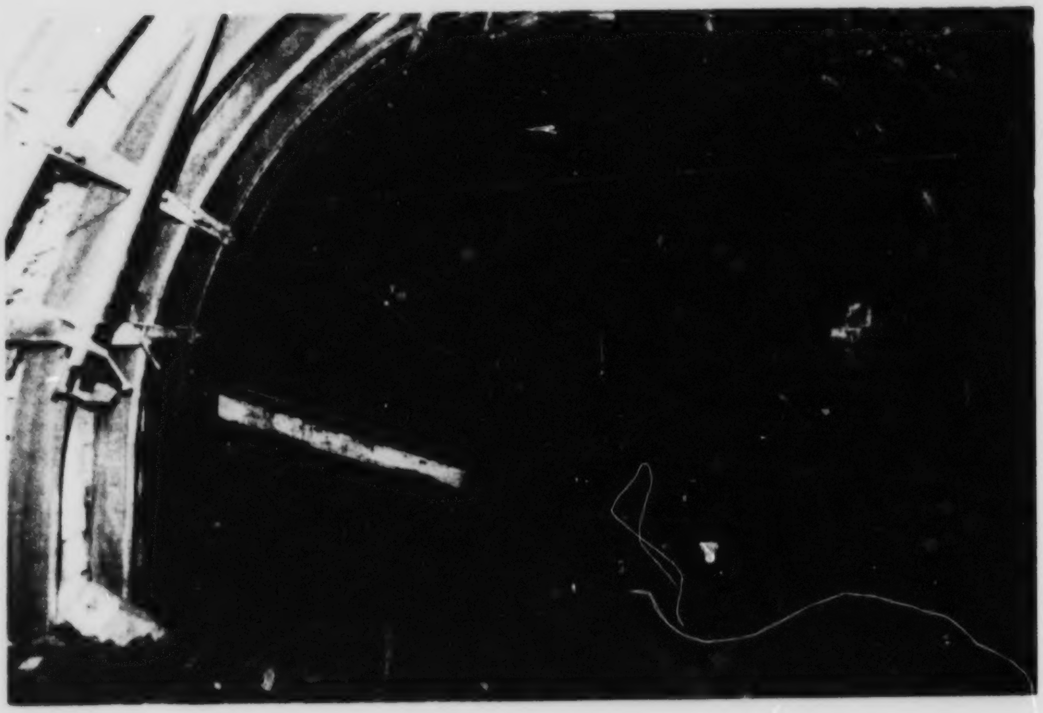
ROCTEST GEO-MONITOR MS3
Filtration Curves

Figure 4.1.1



Lingan Colliery: Typical brushing blast layout
12 East Top Level

Figure 4.2.1

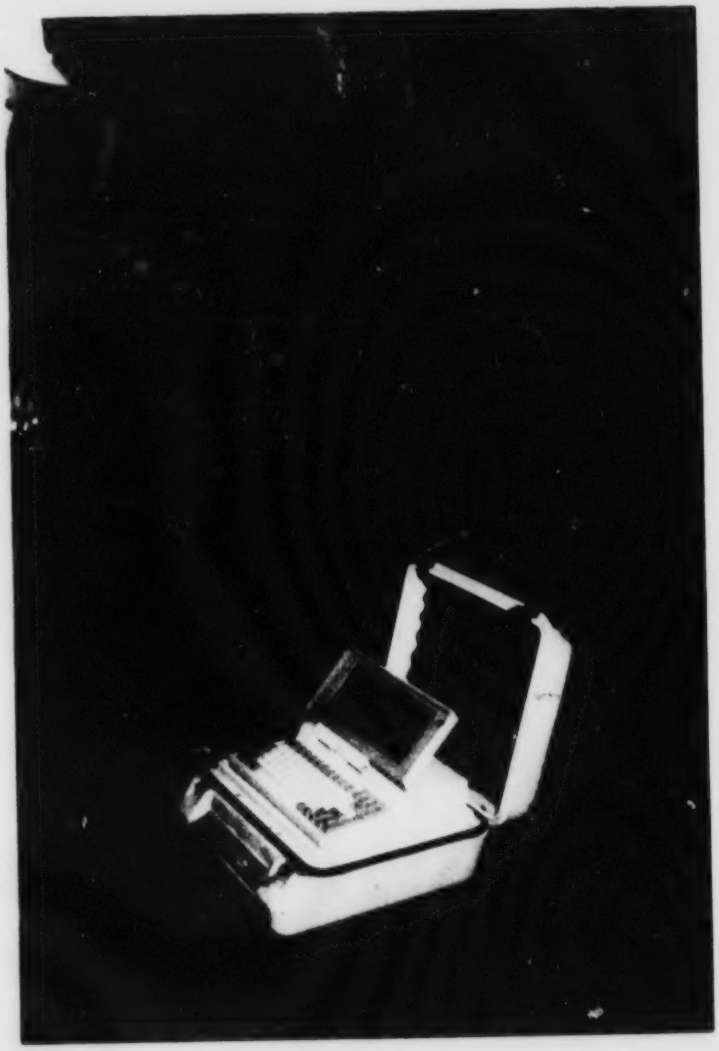


Lingan Colliery: Debris after brushing blast
12 East Top Level

Figure 4.2.2

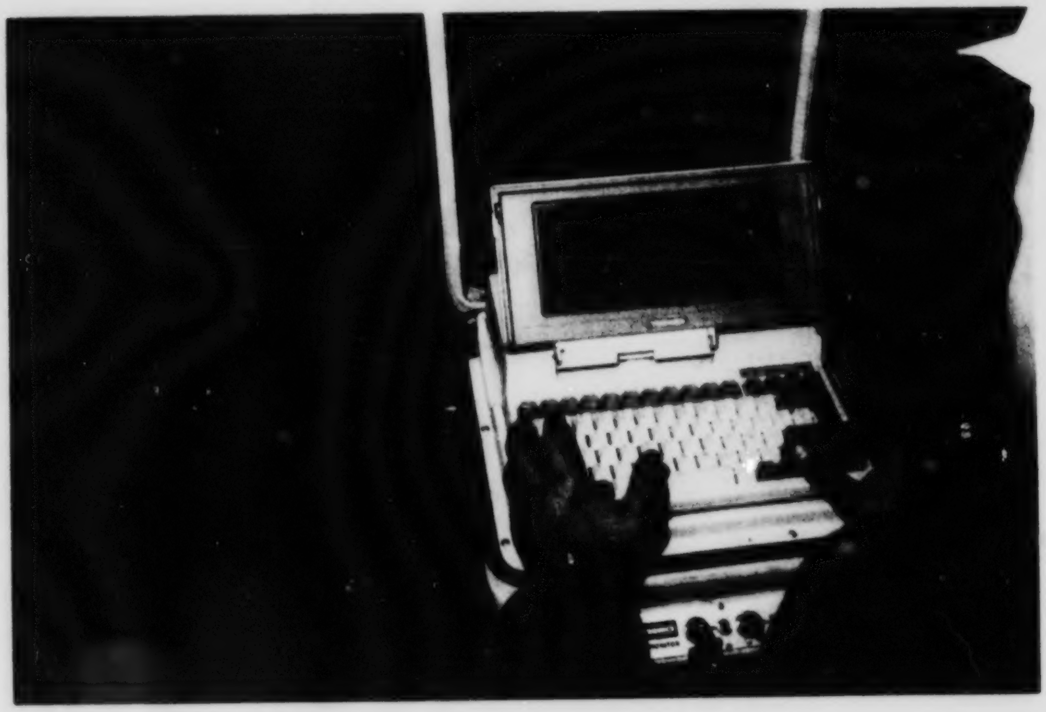
Lingan Colliery: BMX Blast Monitor

Figure 4.2.3



Lingan Colliery: Using the BMX Blast Computer

Figure 4.2.4

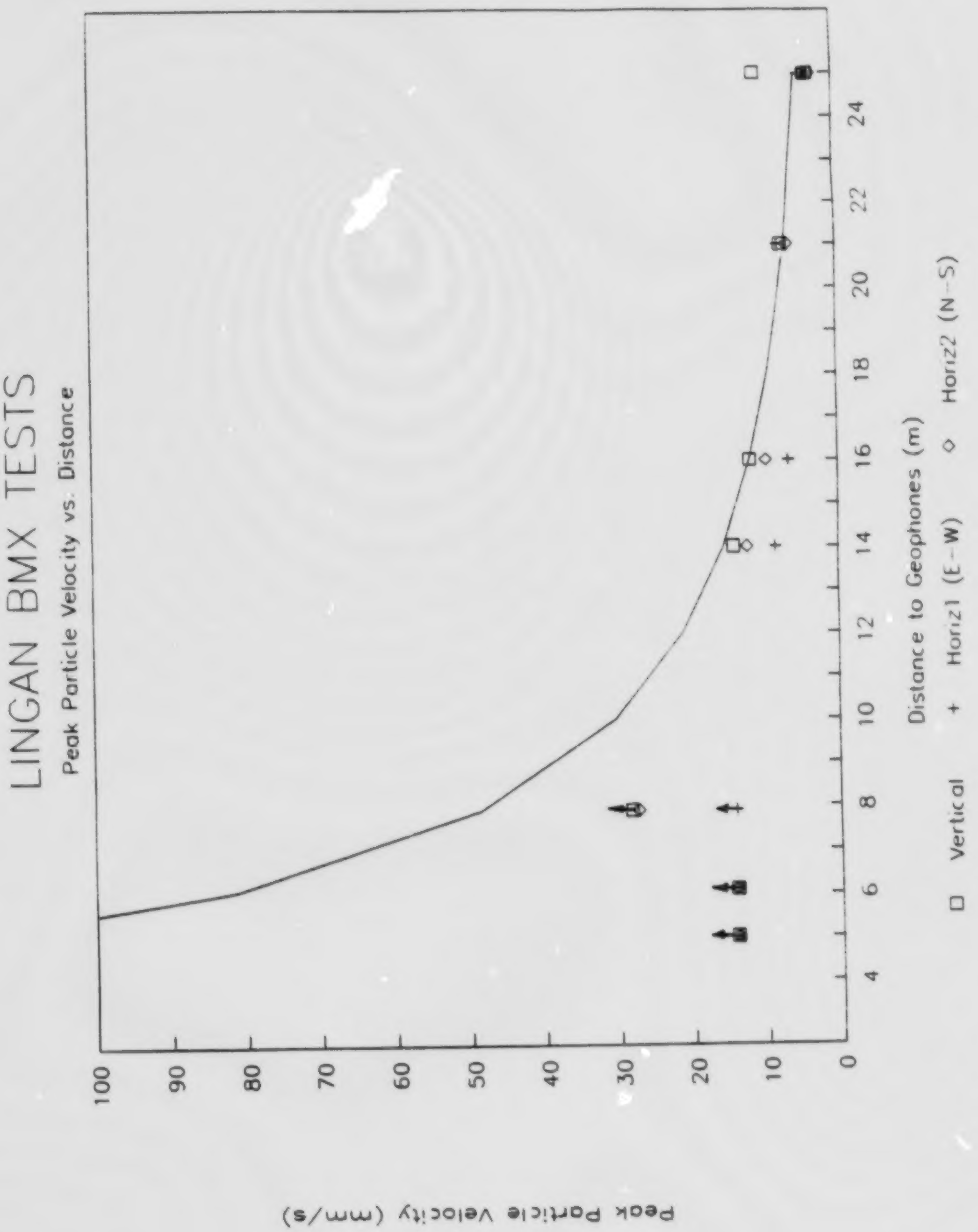


Lingan Colliery: Triaxial Geophone Station in vertical borehole

Figure 4.2.5

LINGAN BMX TESTS
Peak Particle Velocity vs. Distance

Figure 4.2.6



APPENDIX A

Statement of Work for Preliminary Field Trials to Detect Microseismic Activity in Lingan Colliery

APPENDIX "A"

STATEMENT OF WORK

TITLE: PRELIMINARY FIELD TRIALS TO DETECT MICROSEISMIC ACTIVITY IN LINGAN COLLIERY

OBJECTIVE

To identify the presence or absence of microseismic acoustic activity in the strata around roadway drivage operations at Lingan Colliery. If detected, to determine any relationship to the phenonomena of rock/gas outbursts. To do systematic field trials using approved equipment.

REQUIREMENT

On behalf of the Department of Energy, Mines and Resources complete, by March 31, 1992, a series of systematic field trials of microseismic/blast monitoring in Lingan 13 East Bottom Level and wall (face) line drivages.

BACKGROUND

CBDC announced on July 19 intentions to close Lingan Colliery by March 1993. Further revised drivage schedules indicate that the last roadway drivage will take place between August 12 and September 6, 1991 and the last wall line drivage between October 1, 1991 and January 31, 1992. This work is all in relatively close proximity to the rock/gas outburst area at No. 26 Colliery approximately two miles away. This gives added urgency to what is now the final and extremely valuable data collection opportunity for microseismic and blast monitor trials at Lingan in the Harbour Seam at depth in excess of 700 m.

CBDC's mining plans at Lingan and Phalen involve mining significant reserves below 700 m depth. The serious development of rock/gas phenomena in the adjacent No. 26 Colliery below 700 m depth therefore poses a very significant potential hazard to both safety and efficiency. A long-term research program commenced in 1983 (before No. 26 closed due to an unrelated fire). This program has investigated: characterization of the phenomena; analvtical modelling; in situ stress determinations; potential preventive techniques - hydrofracturing; and more recently evaluation of microseismic techniques and assistance in preparation of suitable operational precautionary guidelines.

Research into potential application of microseismic techniques showed that sub-audible microseismic acoustic emissions are often associated with outburst activity. It is recommended that initial investigations proceed at Lingan to determine the parameters for which a possible future full-scale trial could take place. The first step in this process is to carry out small scale tests using a commercially available instrument called an Event Counter. This will form the start of a valuable data base to provide important information related to rock/gas outbursts phenomena.

The second step is to carry out blast monitoring of any drill and blast operations in this burst-prone ground. The purpose of monitoring these blasts is to record the blast vibration waveforms. If burst conditions exist, then it is expected that the blast will trigger minor events before any major events occur. Such minor events would be expected to produce different waveforms and prolonged blast vibrations. Blast monitoring is required to produce these records for analysis.

SCOPE OF WORK

TRAINING

1) The contractor will:

a) Confirm with the Scientific Authority prior to proceeding that written approval has been given by the Coal Mining Safety Commission for use of both the SINCO Geo-Monitor MS-3 Event Counter and the JK Tech Blastronic BMX Blast Monitor. Copies of both applications for approval are attached in Appendix 1 and Appendix 2 respectively.

b) Provide Golders own instrument: The BMX Blast Monitor (Serial No. D11087004) including integral lap-top computer (Toshiba Model T1200, Serial No. 08713063) for use throughout this project.

c) Provide suitable qualified staff to undertake a training program to designated CBCRL and CBDC staff at Lingan Colliery in the application and use of both the Geo-Monitor MS-3 Event Counter and of the BMX Blast Monitor. This training is to include, but not restricted solely to the following:

i) provision of appropriate operating instructions, procedures and guidelines for each instrument.

ii) instruction to enable designated staff to fully, completely, professionally and safely operate the two instruments to adequately collect reliable field data, including appropriate precautions, defaults and contingency plans.

iii) instruction in correct recording and appropriate analysis to check results and derive basic data.

EVENT COUNTER TRIALS

2) The contractor will:

a) Develop in close cooperation with the Scientific Authority and CBDC representative(s), a plan and schedule of suitable field trials of the Geo-Monitor MS-3 Event Counter, during remaining roadway drivage at Lingan scheduled between August 12, 1991 and January 31, 1992.

b) Include in the plan the following:

i) the objective being to establish whether dynamic rock failure is taking place in the rock around the mining operations in 13 East District.

ii) suitable activities to identify and establish:

- The appropriate amplification of 'trigger' level
- The background noise level
- Measurement of acoustic emissions during roadheader drivage
- Measurement of acoustic emissions after suspension of mining operations (i.e. in quiet times)

iii) a schedule of the activities which is compatible with CBDC's own schedule of mining operations and which will absolutely minimize interference with CBDC's operations.

iv) a schedule of designated personnel provided by: the contractor, CANMET (CBCRL) and CBDC as appropriate to successfully carry out the activities in accord with the schedule.

c) under authorization of the Scientific Authority and in agreement with CBDC's Colliery General Manager at Lingan Colliery, mobilize, organize, coordinate and undertake the implementation of the above plan schedule of activites and designated personnel to achieve the objectives, preferably in the early period of the project, i.e. August/September 1991.

d) comply with all appropriate prevailing legislative requirements and CBDC operating instructions in force.

e) take all reasonable steps to ensure safe working practices are adopted throughout.

BLAST MONITOR TRIALS

3) The contractor will:

a) develop, in close collobration with the Scientific Authority and CBDC representative(s) a plan and schedule of suitable field trials of the BMX Blast Monitor, during the remaining roadway drivage at Lingan using both drill/blast and roadheader methods, scheduled between August 12, 1991 and January 31, 1992, but particularly during October 1991.

b) include in the plan the following:

i) the objective being to establish whether dynamic rock failure is occuring, especially at the time of or immediately following blasting.

ii) suitable activities to identify and establish:

- any background noise
- records of the characteristic waveforms and data associated with a normal blast (i.e. no associated dynamic rock failure)
- the occurrence and recording of any additional waveforms and data over and above that due to a normal blast, which may be associated with dynamic rock failure

iii) a schedule of the activities which is compatible with CBDC's own schedule of mining operations and which will absolutely minimize interference with CBDC's operations.

iv) a schedule of designated personnel provided by: the contractor, CANMET (CBCRL) and CBDC as appropriate; to successfully carry out the activities in accord with the schedule.

c) under authorization of the Scientific Authority and in agreement with CBDC's Colliery General Manager at Lingan Colliery, mobilize, organize, coordinate and undertake the implementation of the above plan schedule of activities, designated personnel to achieve the objectives. Every attempt should be made to monitor every blast in the remaining drivage of 13 East District, especially if indications of dynamic rock failure have occurred.

d) comply with all appropriate prevailing legislative requirements and CBDC operating instructions in force.

e) take all reasonable steps to ensure safe working practices are adopted throughout.

COMPATIBILITY

4) The contractor will take all reasonable steps to ensure the smooth integration and compatibility of items 2 and 3 above, which inevitably must be undertaken in parallel with each other. Any problems, actual or foreseen, should be brought to the attention of the Scientific Authority and CBDC representative(s) immediately.

ANALYSIS OF RESULTS

5) The contractor will analyse and evaluate the results of the monitoring trial to fully address the following questions:

   i) Is there seismoacoustic activity following the test blasts and is this activity relevant from the point of view of the sandstone-gas outbursts which were experienced at the No. 26 Colliery?

   ii) Is there seismoacoustic activity during and immediately after the roadheader advance and is this activity relevant from the point of view of the sandstone-gas outbursts which were experienced at the No. 26 Colliery?

   iii) What are the characteristics of this seismoacoustic activity and how do they compare to a test blast? Could the seismoacoustic activity provide a trigger for a sandstone-gas outburst?

   iv) Identify any implications of the findings on ongoing mining operations.

This work will be summarised in an interim report in November 1991.

The contractor will:

- recommend and carry out, under the authorisation of the Scientific Authority, any further tests to refine the initial results and produce more meaningful findings.
- recommend further testing requirements in the longer term (e.g. Phalen @ 800 m depth).

REPORT

6) Include all of the above in the final report to be provided to the Scientific Authority by March 31, 1992.

FIELD VISITS

7) Site visits to operating mines, research groups and centers of related expertise, etc. will only be made with the prior written approval of the Scientific Authority.

The work plan should include sufficient field trips to Cape Breton to ensure that adequate field data is obtained to draw meaningful conclusions, and to carry out an adequate debriefing. The number of field trips is likely to be between 4 and 6 but will be agreed between the Contractor and the Scientific Authority as the project progresses.

FACILITIES TO BE PROVIDED TO THE CONTRACTER

The Scientific Authority will provide the contractor with the following:

- SINCO Geo-Monitor, MS-3 Event Counter
- liason between the contractor and CBDC to ensure access to CBDC Lingan Colliery as required and services of appropriate designated CBDC personnel to assist in the field trials, if required.

CBDC services are provided under the separate Joint Collaboration Research Program between CBCRL and CBDC.

TIME SCALE

Project start-up is requested as soon as possible on August 12, 1991. Typical schedule would therefore be mid-August 1991 to end January 1992, subject to site availability and operational factors at Lingan Colliery. Final report by March 1992.

REPORTS

The contractor will provide a summary evaluation and findings report outlining all the work carried out in the field trial. This will be in two parts:

i) interim report (covering initial trials) in November 1991

ii) final report

The contractor will provide fifteen (15) copies of the final report to be submitted at the conclusion of the work and before March 31, 1992.

The report shall be subject to inspection by the Scientific Authority prior to acceptance, who may require correction if not in accordance with this contract.

DEBRIEFING

A contract debriefing seminar shall be given after acceptance of the final report. This intention is to present the methodology and findings to an invited audience with representatives from industry and other interested parties. This will be held at CBCRL offices before March 31, 1992.

APPENDIX B

Technical Details: Roctest Geo-Monitor MS3

INSTRUCTION MANUAL

GEO-MONITOR

MODEL MS-3

ROCTEST

665 PINE, ST-LAMBERT, QUÉ. J4P 2P4
TÉL. (514) 465-1113

GEO-MONITOR

MODEL MS-3

TABLE OF CONTENTS

GENERAL INFORMATION

- 1.) Introduction
- 2.) Specifications

OPERATING INSTRUCTIONS

- 1.) Internal Batteries
- 2.) Transducer
- 3.) Geo-Monitor

MAINTENANCE

- 1.) Recharging Battery

FIGURES AND DIAGRAMS

INSTRUCTION MANUAL
GEO-MONITOR
MODEL MS-3

GENERAL INFORMATION

1.) Introduction

The Model MS-3 GEO-MONITOR is a highly sensitive detector of sub-audible acoustic emission from in-situ rock and soil stress. The information acquired by the MS-3 can be used to evaluate the relative activity and potential failure of monitored materials and areas. The extreme sensitivity of the MS-3 permits application to: Stability studies of excavation walls, tunnels, mines, glacial areas, and slides; location of leakage paths in dams, reservoirs, and pipe lines; warning of overstress to structural components; and activity studies of volcanic areas and fault zones.

The MS-3 is a portable, battery operated system complete with transducer, cable, earphones, amplifier, filter, event counter, rate counter, analog output and battery charger.

Two sizes of transducers are available: A 1.875-inch (48mm) diameter unit for NX or larger boreholes, and a .875-inch (22mm) diameter unit for small, jackhammer size holes. Both sizes can be used interchangeably.

Transducer output is high level, low impedance, and capable of driving cable lengths of more than 1,000 feet (300M). The standard aluminum transducer housing is sealed to withstand water pressures up to 200 psi (1400 kPa). A stainless steel housing is available for permanent burial, and for use in corrosive conditions and water pressures up to 500 psi (3500 kPa).

The integral event counter records each occurrence of an event above the adjustable threshold level. The rate counter conveniently measures the events per minute for either a one minute or ten minute sample period.

2.) Specifications

Sensitivity:	10 db signal/noise for 1 µbar pressure input signal.
Transducer Output:	-40 dbv/µbar (.01v/µbar). - 53305 -54 dbv/µbar (.002v/µbar).- 53306
Frequency Response:	2 Hz to 17 kHz (±3db)
Overall Gain:	126 db nom. (2×10^6)
Preamp Gain:	54 db min. (500)
Amplifier Gain:	66 db min. (2,000)
Amp. Input Impedance:	500 ohms
Tape Output:	5 volt peak to peak maximum into 10 K ohm or greater impedance.
Filters:	
High Cut:	-3 db point selectable at 10 KHz, 1 KHz, and 100 Hz for 40 db per decade roll-off.
Low Cut:	-3 db point selectable at 100 Hz, 1 KHz, and 10 KHz for 40 db per decade roll-off.
Event Counter:	1×10^6 counts resettable
Rate Counter:	Maximum 1,000 counts/minute
Operating Time:	24 Hours on Internal Batteries
Power Requirements:	115/230 VAC 50/60 Hz for charger External 11 - 14.7 VDC at 150 MA Avg.
Temperature Range:	0°F to 122°F (-18°C to +50°C)
Instrument Weight:	14 Pounds (6.4 kg)
Instrument Case Size:	10" H x 7" W x 11" L (250mm x 180mm x 28

Transducers:	Outside Diameter:	Length:	Weight:
53305	1.875-in. (48mm)	3.25-in. (83mm)	0.8 lbs (0.4k
53306	.875-in. (22mm)	6.62-in. (168mm)	0.4 lbs (0.2k

OPERATING INSTRUCTIONS

1.) Internal Batteries

Before taking the instrument out in the field, check the battery voltage. Depress battery test switch. The meter should read at least 12 volts for fully charged batteries. Do not operate instrument when voltage is below 10.5 volts. Refer to MAINTENANCE Section for recharging instructions.

Either AC power or an external 12 VDC battery can be used to extend the operating time of the instrument.

2.) Transducer

CAUTION: Transducers contain a sensitive piezoelectric ceramic element and transistorized preamplifier which should not be subjected to shock or excessively rough treatment.

The transducer responds to pressure variations and requires fluid coupling for best results. In highly permeable, dry soils the transducer may be buried in compacted soil or a plastic casing may be installed to retain water.

Installations should be at least two feet below the surface to avoid excessive surface noise. The top of the borehole should also be packed with sound absorbing material to further reduce surface noise.

Flowing or dripping water into a borehole can also cause unwanted noise.

3.) Geo-Monitor

Plug transducer cable into input receptacle.

Depress battery test switch. Do not operate instrument when voltage is below 10.5 volts. Refer to MAINTENANCE Section for recharging instructions.

Place the MS-3 controls as follows:

Trigger Level..........10
Counters...............OFF
High-Cut...............Norm
Low-Cut................Norm
Gain...................1
Volume.................1
Power..................ON

If the ambient noise level is low (little or no meter deflection), switch the gain control to the next higher position to provide increased sensitivity. Increase the gain until a meter deflection between 1 and 5 is observed.

Plug a set of earphones into either of the earphone jacks on the front panel and adjust the volume control to provide a comfortable listening level.

In certain conditions it may be necessary to filter out various types of interfering noise by use of the bandpass filter or to select a particular frequency range to emphasize a particular noise phenomena. Refer to Fig. 2, which shows relative gain versus frequency for various filter settings.

As an example, if there were a noticeable audible signal of 60 Hz interference, it could be reduced by switching the low-cut filter to the 100 Hz or 1 KHz position. In the 1 KHz position, the 60 Hz interfering signal would be attenuated approximately 43 db, as shown in Fig. 2.

A high impedance tape output (load impedance not less than 10 K ohms) is provided on the front of the plug-in amplifier panel. This output jack is used when an analog record, such as provided by a tape recorder, is desired. Adjust the recorder's gain control for proper level. The earphone volume level and trigger level have no effect on the tape output level.

The total count and rate count are both activated by the counters switch. These counters record the number of noise events that exceed a pre-set trigger level.

To adjust the threshold point for the counters, start with the "Trigger Level" control fully clockwise and turn it counter-clockwise until the background noise just begins to trigger the counter. Now, increase the "Trigger Level" clockwise to a level just above the ambient noise. The closer the control is left to the critical threshold level, the weaker the noise that will be required to trigger the counter.

Since the counter produces an audible "click" when it records an event, it must then be acoustically isolated from the transducer. If the transducer hears this "click", feedback will occur.

To initiate operation of the rate counter, set selector switch in 1 minute or 10 minute position as desired, then move READ switch to its upper position. The counter should be reset to zero. Move switch to READ position to commence counting for 1 minute or 10 minute interval. When the interval has timed out, the LED light above the switch will turn on. The total count of events for that interval is displayed. The decimal point is automatically positioned to indicate events/minute.

MAINTENANCE

1.) Recharging Battery

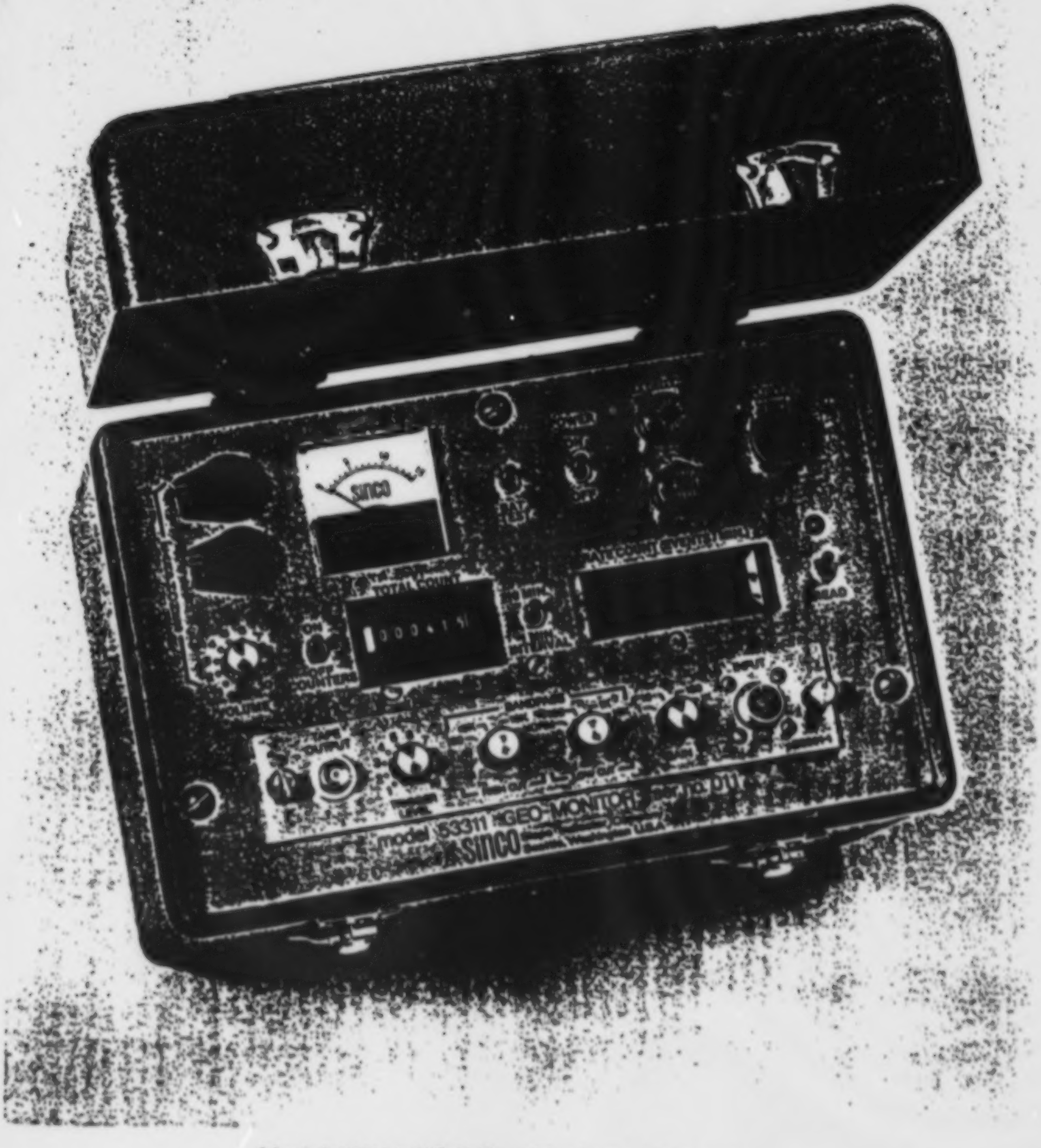
Using the AC cable provided, plug into suitable 115/230 VAC 50/60 Hz outlet and connect to power connector on the front panel. With the power switch OFF, the internal battery will recharge to 80% of rated capacity in 16 hours or less. Approximately 48 hours are required to fully recharge the battery. The charger should not be left connected for any extended period of time. This will prevent the battery from being over-charged and will insure optimum battery performance and life. When the instrument is not in use, it should be recharged at least once every three months.

2.) Electrical Connectors

To ensure good electrical contact, periodically wipe contacts with clean dauber or cloth dipped in alcohol.

Before disconnecting cables, carefully wipe the exterior of connector to remove water and dirt. When disconnected, always keep protective caps over contacts.

Do not spray oil on connectors, since this will damage the insulator.


sinco
TOTAL COUNT
COUNTERS
TAPE OUTPUT
INPUT
READ
model 53311 GEO-MONITOR
sinco

Model 53311 MS-3 Geo-Monitor with Counters

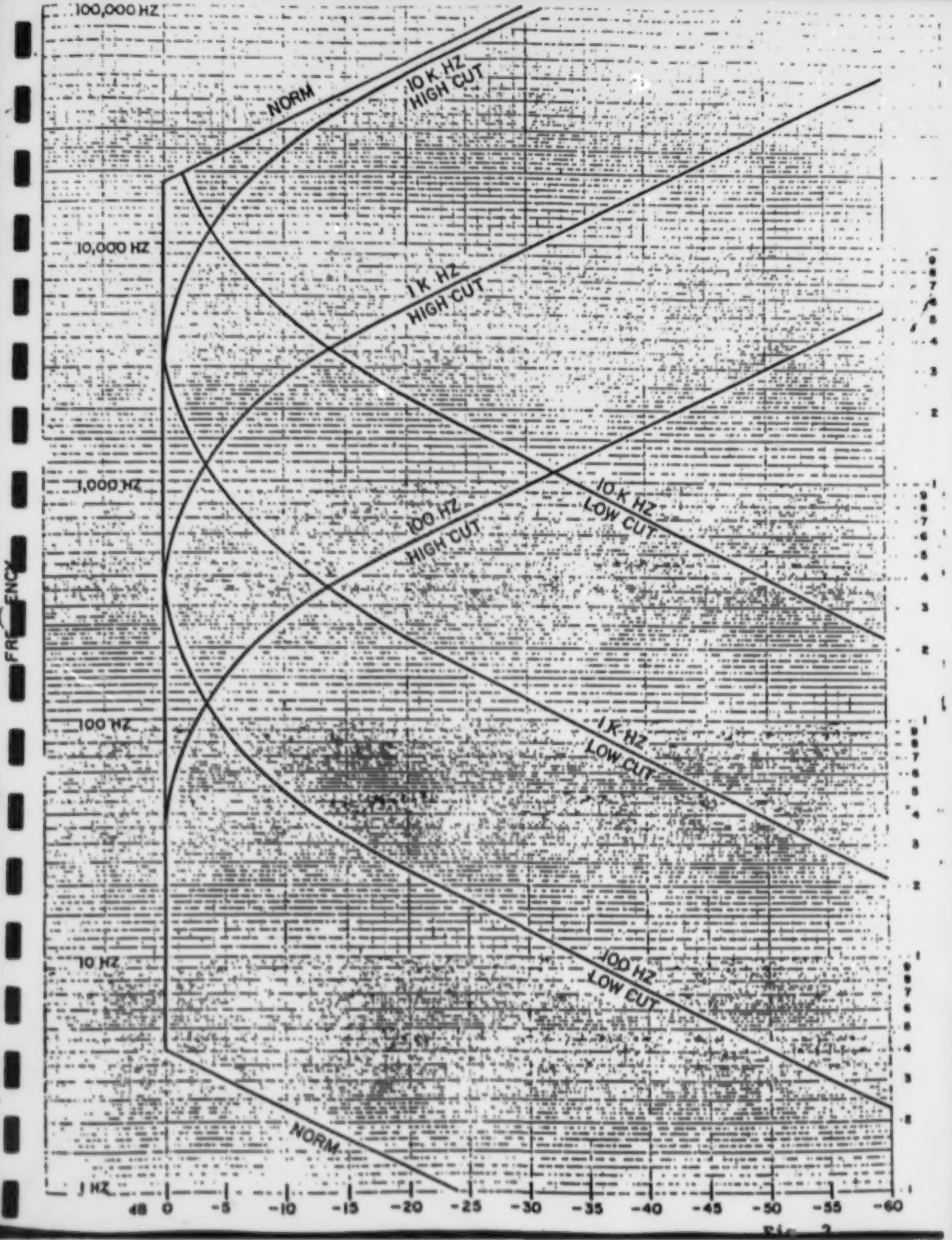
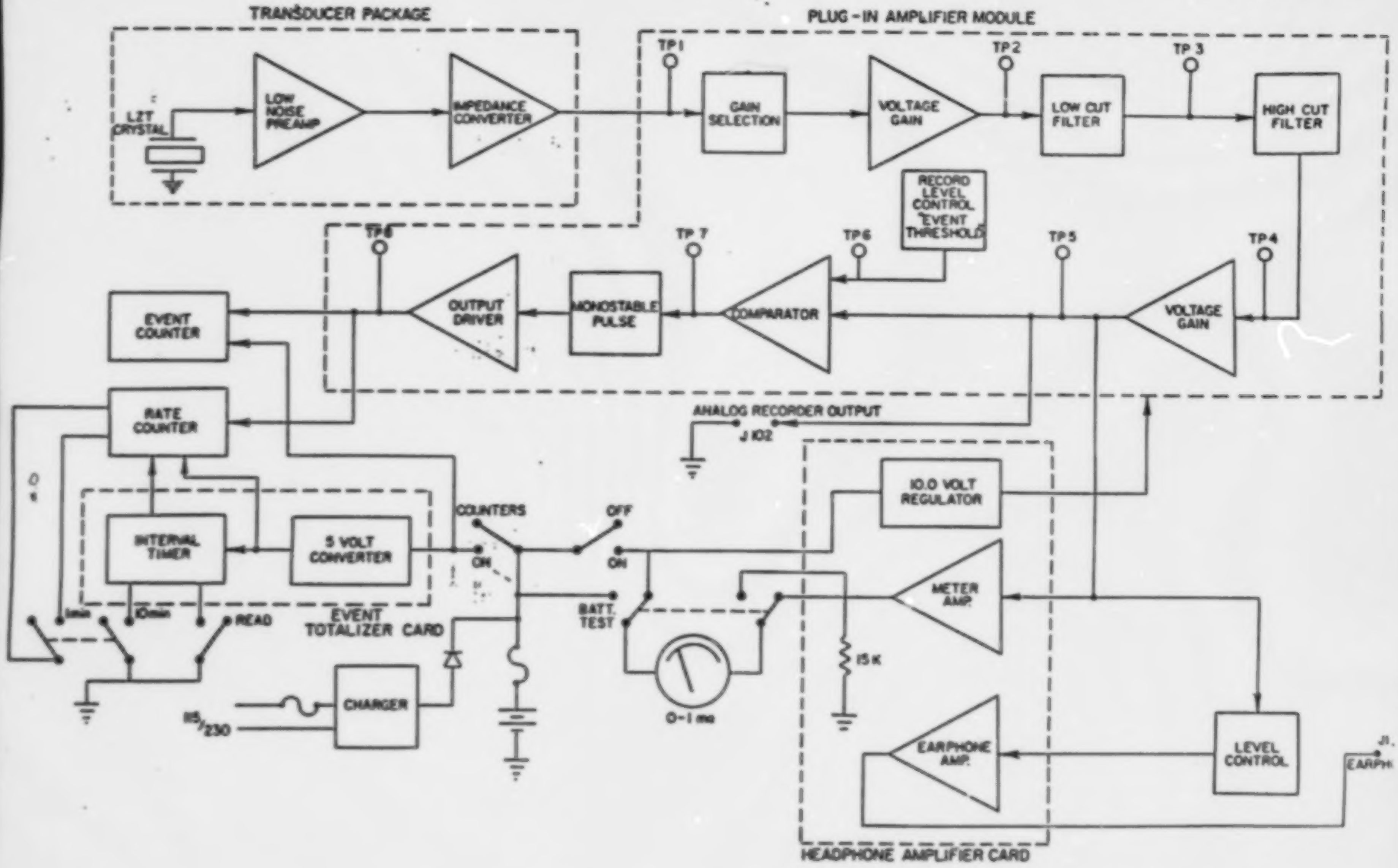

100,000 HZ
10,000 HZ
1,000 HZ
100 HZ
10 HZ
1 HZ
FREQUENCY
NORM
10 K HZ HIGH CUT
1 K HZ HIGH CUT
100 HZ HIGH CUT
10-K HZ LOW CUT
1 K-HZ LOW CUT
100 HZ LOW CUT
NORM
dB
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60

Fig. 2


TRANSDUCER PACKAGE
LZT CRYSTAL
LOW NOISE PREAMP
IMPEDANCE CONVERTER
PLUG-IN AMPLIFIER MODULE
TP1
GAIN SELECTION
VOLTAGE GAIN
TP2
LOW CUT FILTER
TP3
HIGH CUT FILTER
RECORD LEVEL CONTROL "EVENT THRESHOLD
TP8
TP 7
TP6
TP5
TP4
EVENT COUNTER
OUTPUT DRIVER
MONOSTABLE PULSE
COMPARATOR
VOLTAGE GAIN
RATE COUNTER
ANALOG RECORDER OUTPUT
J 102
10.0 VOLT REGULATOR
COUNTERS
OFF
ON
ON
INTERVAL TIMER
5 VOLT CONVERTER
1min
10min
READ
EVENT TOTALIZER CARD
BATT. TEST
METER AMP.
15 K
CHARGER
115/230
0-1 ma
EARPHONE AMP.
LEVEL CONTROL
J1
EARPH
HEADPHONE AMPLIFIER CARD

MS-3 BLOCK DIAGRAM
GEO-MONITOR
53311

MS3 EVENT COUNTER RECORD

PROJECT: 911-1732
Page 1/3

DATE: August 20, 1991
TIME: Tests began at 06:13
SITE: Lingan Colliery – 13 East Bottom Level
REMARKS: Tests to determine the characteristic noise level of the
Voest-Alpine Continuous Miner when cutting coal & stone
Sensor installed in vertical hole in back (@7m from face)

COUNTER RECORD:

START TIME	TRIGGER LEVEL %	AMP GAIN	FILTERS		EVENTS /100s	REMARKS
			HIGH	LOW		
06:13	50	1k	N	N	690	Quiet
06:15	50	1k	100	N	26	Quiet
06:17	50	1k	1k	100	6	Quiet
06:20	50	1k	10k	1k	5	Small events heard
06:22	50	1k	N	10k	19	Quiet, small events heard
06:24	50	1k	100	N	22	Quiet, small events heard
06:25	50	1k	1k	100	10	Quiet, small events heard
06:26	50	1k	10k	1k	0	Quiet, small events heard
06:28	50	1k	N	10k	1	Quiet, small events heard
06:30	50	1k	N	N	849	
06:32	20	100	N	N	1	
06:34	20	100	100	N	0	
06:36	20	100	1k	100	NR	
06:38	80	1k	N	N	200	Waiting for shot from 13 East Top Level brushing
06:40	80	1k	N	N	416	Waiting for shot from 13 East Top Level brushing
06:43	80	1k	N	N	343	Waiting for shot from 13 East Top Level brushing
06:45	80	1k	N	N	344	Waiting for shot from 13 East Top Level brushing

APPENDIX C

Results from Roctest Geo-Monitor MS3

MS3 EVENT COUNTER RECORD

PROJECT: 911-1732
Page 2/3

DATE: August 20, 1991
TIME: Tests began at 06:13
SITE: Lingan Colliery – 13 East Bottom Level
REMARKS: Tests to determine the characteristic noise level of the Voest–Alpine Continuous Miner when cutting coal & stone
Sensor installed in vertical hole in back (@7m from face)

COUNTER RECORD:

START TIME	TRIGGER LEVEL %	AMP GAIN	FILTERS HIGH	FILTERS LOW	EVENTS /100s	REMARKS
06:47	80	1k	N	N	349	Waiting for shot from 13 East Top Level brushing
06:	80	1k	N	N	518	Waiting for shot from 13 East Top Level brushing
06:	80	1k	N	N	396	Waiting for shot from 13 East Top Level brushing
06:	80	1k	N	N	515	
06:56	20	100	1k	100	4	
06:57	20	100	N	10k	1	
06:58	20	100	1k	100	1	
06:	20	100	N	10k	0	
06:	20	100	N	N	0	Broad band again
06:	20	100	100	N	0	
06:	20	100	1k	100	NR	
07:09	50	1k	N	N	883	Small 'pop' heard
07:14	20	100	1k	100	1	Back to sequence
07:16	20	100	10k	1k	0	
07:19	20	100	N	10k	0	
07:	50	1k	N	N	949	
07:24	50	1k	100	N	67	

MS3 EVENT COUNTER RECORD

PROJECT: 911-1732
Page 3/3

DATE: August 20, 1991
TIME: Tests began at 06:13
SITE: Lingan Colliery - 13 East Bottom Level
REMARKS: Tests to determine the characteristic noise level of the Voest-Alpine Continuous Miner when cutting coal & stone Sensor installed in vertical hole in back (@7m from face)

COUNTER RECORD:

START TIME	TRIGGER LEVEL %	AMP GAIN	FILTERS HIGH	FILTERS LOW	EVENTS /100s	REMARKS
07:27	50	1k	1k	100	6	
07:	50	1k	10k	1k	6	
07:29	50	1k	N	10k	4	
07:32	50	1k	N	N	883	
07:34	50	1k	N	N	871	
07:36	50	1k	100	N	52	
07:38	50	1k	1k	100	17	
07:40	50	1k	10k	1k	3	
07:42	50	1k	N	10k	6	
07:45	50	1k	N	N	926	
07:47	50	1k	N	N	878	Arch fell
07:	50	1k	N	N	887	

MS3 EVENT COUNTER RECORD

PROJECT: 911-1732

DATE:
TIME: Tests began at 08:30
SITE: Lingan Colliery – 13 East Bottom Level
REMARKS: First underground MS3 trials to establish amplifier gain/filter settings
and background noise levels
Sensor wedged behind slab on roof

COUNTER RECORD:

START TIME	TRIGGER LEVEL %	AMP GAIN	FILTERS HIGH	FILTERS LOW	EVENTS /100s	REMARKS
08:nn	30	100	N	N	81	Conveyor running only – background noise
08:nn	30	100	N	N	72	Conveyor running only – background noise
08:nn	30	100	N	N	4	Quiet in level – nothing running
08:nn	30	100	N	N	0	Quiet in level – nothing running
08:nn	30	100	N	N	21	Acoustic noise – workers moving
08:nn	30	100	N	N	7	Quiet in level – nothing running
08:nn	30	100	N	N	3	Quiet in level – nothing running

MS3 EVENT COUNTER RECORD

PROJECT: 911-1732

DATE:
TIME: Tests began at 10:17
SITE: Lingan Colliery – 13 East Bottom Level
REMARKS: First underground MS3 trials to establish amplifier gain/filter settings and background noise levels
Sensor wedged behind slab on roof

COUNTER RECORD:

START TIME	TRIGGER LEVEL %	AMP GAIN	FILTERS HIGH	FILTERS LOW	EVENTS /100s	REMARKS
10:17	40	100	N	N	1603	Machine cleaning floor in loose coal
10:21	40	100	N	N	1170	Machine cleaning floor in loose coal
10:23	40	100	N	100	1778	Cleaning floor then cutting
10:23	40	100	N	1k	540	Machine cutting
10:25	40	100	N	10k	87	Machine cutting
10:27	40	100	100	N	33	Machine cutting
10:30	40	100	1k	100	1249	Machine cutting
10:33	40	100	10k	1k	612	Machine cutting
10:34	40	100	N	10k	93	Machine cutting
10:36	40	100	100	N	1289	Machine cutting
10:38	40	100	1k	100	742	Machine cutting then cleaning floor
10:40	40	100	10k	1k	4	Machine cutting then cleaning floor
10:41	40	100	N	N	1660	Machine cutting then cleaning floor
10:43	40	100	100	N	865	Machine cutting then cleaning floor
10:45	40	100	1k	100	NR	Machine stopped

MS3 EVENT COUNTER RECORD

PROJECT: 911-1732
Page 1/2

DATE: November 18, 1991
TIME: Tests began at 17:20
SITE: Lingan Colliery – 13 East Wall Road (Up)
REMARKS: Tests to determine the characteristic noise level of the Voest-Alpine Continuous Miner when cutting coal & stone
Sensor installed in vertical hole in back (@7m from face)

COUNTER RECORD:

START TIME	TRIGGER LEVEL %	AMP GAIN	FILTERS HIGH	FILTERS LOW	EVENTS /100s	REMARKS
17:20	50	100	N	N	1	Quiet time before mining starts
17:21	50	100	N	N	8	Moving machine
17:22	50	100	N	N	0	Only conveyor belt running
17:24	50	100	N	N	0	Only conveyor belt running
17:26	50	100	N	N	1	Only conveyor belt running
17:29	50	100	N	N	0	Only conveyor belt running
17:31	50	100	N	N	0	Only conveyor belt running
17:33	50	100	N	N	0	Only conveyor belt running
17:34	50	100	N	N	0	Only conveyor belt running
17:45	50	100	N	N	0	Only conveyor belt running
17:	50	100	N	N	228	Cutting coal
17:	50	100	N	N	859	Cutting coal
17:	50	100	N	N	392	Cutting stone (recorded by BMX file 05)
17:	50	100	N	N	354	Cutting stone then stopped (recorded by BMX file 06)
17:	50	100	N	N	261	Machine stopped
17:	50	100	N	N	14	Machine stopped
18:19	50	100	N	N	1018	Cutting stone (recorded by BMX file 07)
18:	50	100	N	N	256	Cutting coal
18:	50	100	N	N	589	Cutting stone (recorded by BMX file 08)

MS3 EVENT COUNTER RECORD

PROJECT: 911-1732
Page 2/2

DATE: November 18, 1991
TIME: Tests began at 17:20
SITE: Lingan Colliery – 13 East Wall Road (Up)
REMARKS: Tests to determine the characteristic noise level of the Voest-Alpine Continuous Miner when cutting coal & stone
Sensor installed in vertical hole in back (@7m from face)

COUNTER RECORD:

START TIME	TRIGGER LEVEL %	AMP GAIN	FILTERS HIGH	FILTERS LOW	EVENTS /100s	REMARKS
18:	50	100	N	N	125	Cutting coal
18:30	50	100	N	N	714	Cutting coal and stone (recorded by BMX file 09)
	50	100	N	N	376	Cutting coal and stone
	50	100	N	N	79	Quiet (recorded by BMX file 10)

APPENDIX D

Technical Details: BMX Blast Monitor

BLASTRONICS

BMX BLAST MONITOR

Harnessing technology for cost-effective blasting

BLASTRONICS
BMX BLAST MONITOR

THE BLASTRONICS BM
A major breakthroug

PLICATIONS AND BENEFITS

plosive wastage, due largely to initiation problems, is com- n in large scale blasting, resulting in poor fragmentation and duced cost effectiveness. **Misfires and other charge malfunctions can be eliminated once they have been positively identi- d.** The BLASTRONICS BMX MONITOR was designed after arly 10 years of research and on-site blast monitoring to entify the inefficient usage of explosives in blasting. The following benefits to large mining companies have been achieved:

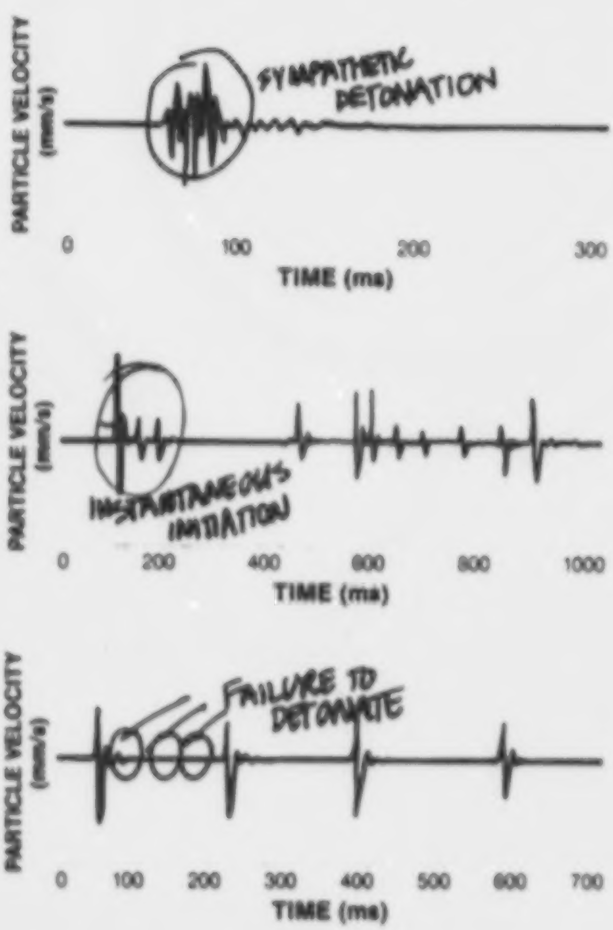
- up to 50% reduction in explosive consumption
- up to 50% reduction in drilling costs
- reduced overbreak and blast damage (ground support costs)
- reduced ore dilution
- improved fragmentation
- improved control over surface ground vibrations and overpressure.

he blast monitor records at right illustrate the ease with ch initiation problems can be detected using the **BLAS- ONICS BMX MONITOR,** with the designed initiation sequence superimposed on the actual blast record. This infor- tion is available to the blast operator within minutes of retriev- the monitor after blasting, via the user friendly analysis ftware within the monitor. The monitor records also show how a well-controlled initiation will appear after initiation problems ve been resolved. See illustration at far right.

he **BLASTRONICS BMX MONITOR** is designed for **every- y use by mine operators,** for any type of blasting, anywhere in the mine.

dditional features of the monitoring which are relevant to st design and optimisation include:

- measurement of vibration levels from separate explosive charges
- measurement of the performance of different types of explosives
- investigation of the accuracy of delays in full scale blasting
- application to production blasting and development blasting
- documented paper copies of each blast, showing comparison between designed and actual sequencing, via optional printer.



Most common forms of charge malfunctions

MX BLAST MONITOR
gh in blast diagnosis

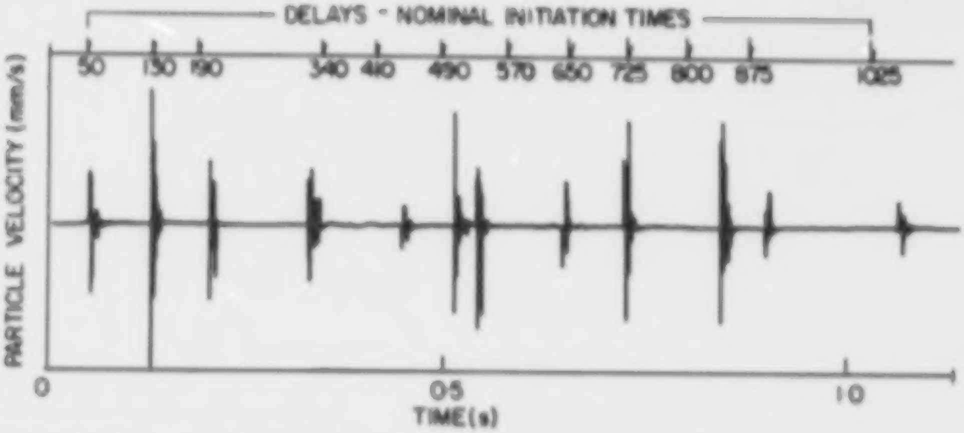
GENERAL DESCRIPTION

The **BLASTRONICS BMX MONITOR** is a light-weight, fully digital, self-powered, multi-channel recorder for the collection and analysis of blast vibration waveforms. Highly interactive computer software eases the user through detailed diagnosis of initiations and identifying explosive initiation and detonation problems including sympathetic detonation, instantaneous initiation, failure of charges to initiate, and reduced detonation efficiency. The monitor is different from other monitoring systems in that the **objective is to directly reduce blasting costs** by ensuring the maximum performance of each charge in a blast pattern. The main differences between the **BLASTRONICS BMX MONITOR** and other systems are:

- Sensors are placed close to the blast (< 20m) for maximum detail
- Sensors are rigidly coupled to the rock
- Extended memory permits full recording for blasts up to 65 second duration, depending on sampling rate
- High speed digital recording permits accurate vibration reproduction
- Lightweight, robust construction permits easy use anywhere in the mine
- User friendly software permits use by blasting operators.

The system consists of a vibration sensor, a cabling network, and the computer based monitor. Any sensor (accelerometers or geophones) of known response can be used with the **BLASTRONICS BMX MONITOR,** but for definitive blasting records, the sensor must have a frequency response which is flat from approximately 10 Hz to 2 kHz. It is readily usable by engineer and blasting foreman alike, and provides an assessment of the efficiency of initiation within minutes after retrieval of the instrument.

The **BLASTRONICS BMX MONITOR** incorporates an IBM compatible laptop computer which is used to program the monitor for data capture, and to provide detailed documentation of the event. It can also be used to develop specific analysis software such as frequency analysis, or for reduction of data for vibration modelling. Blastronics programmers are engaged in the ongoing development of data processing software, and can customise programs for specific user requirements. After programming, the laptop computer may be either removed or left with the monitor. Data collected by the monitor will be held safely in CMOS memory for up to 12 hours. Inadvertent triggering of the monitor by noise is avoided by using the wirebreak trigger, a failsafe method of triggering linked to the starting detonator. The monitor is therefore able to wait in an armed and ready-to-record state for many hours prior to blasting. For surface monitoring or remote monitoring, a threshold trigger with 14 discrete triggering levels is provided.



Controlled blast free from misfires — actual underground production blast

SPECIFICATIONS

DATA CHANNELS	From 1 to 8 (factory set as per order)
Resolution	8 Bits (1 in 256 or 0.4%)
Sampling	

Frequency	Interval	Record Time (sec.)
200 kHz	5 µsec	0.33
100 kHz	10 µsec	0.66
50 kHz	20 µsec	1.3
20 kHz	50 µsec	3.3
10 kHz	100 µsec	6.6
5 kHz	200 µsec	13.2
2 kHz	500 µsec	32.8
1 kHz	1 msec	65.6

Input Voltage	8 ranges: 0.3, 0.6, 1.2, 2.4, 4.8, 9.6, 19.2, 38.4 Volts (corresponds to 10, 20, 40, 80, 160, 320, 640, 1280 mm/s for re-usable geophone transducer supplied with unit). Ranges for other sensors depend on sensor sensitivity.
Triggering	14 Levels of Threshold trigger on each channel, or single Wirebreak trigger.
ATTERIES	2 x 6v integral, rechargeable gel cells, 2.6 Ahrs 12 hours operation from fully charged (24 hr option available). Estimated minimum battery life 3 years in normal service. External DC connection facility for extended operating time.
RESIDENT SOFTWARE (Menu system)	**Edit:** document a record, set amplifier gains, triggering method and sensor calibration. **Initialise:** prepare system for data capture. **Disk storage:** Download data to floppy disk. **Enter:** input nominal delays for comparison with actual delays on vibration trace. **View/Analyse:** display vibration waveforms on screen and tabulate delay times and vibration levels for each charge. Plot or compare traces from different blast records. Output to optional printer.
DIMENSIONS	440mm (l) x 380mm (w) x 210mm (h) excluding handle.
WEIGHT	15 kg
INTERNAL COMPUTER	Toshiba T 1100 Plus, 7.16 MHz, 640 kB RAM, dual 720 kB disk drives, IBM compatible, battery powered, RS-232, RGB Colour Video and composite CRT ports.
OPTIONS	External graphics mode printer: Epson MX80 and compatibles, IBM ProPrinter and compatibles. Other printers may be supported — please contact supplier for details.

LASTRONICS PRODUCT LIST SEPTEMBER 1986

MX BLAST MONITOR SYSTEM

[illegible] BMX [illegible] BMX Software [illegible] 50 metre [illegible] junction box and connectors [illegible] and [illegible] transport [illegible]

EXTRA CH[illegible] CARDS FOR BMX SYSTEM

[illegible] 8 channel cards

[illegible]CEMENT

[illegible] T1200 [illegible]

[illegible]ADE FOR BMX

[illegible] individual channel timebase and [illegible] max to 10 changes

TX SOFTWARE

New software [illegible] hardware

MATH[illegible]SOFTWARE

[illegible] Max [illegible] Energy

TRUNKLINE CABLE NETWORK

[illegible] cable and connections to suit various applications. Gauge [illegible] 4 channel). Trunk [illegible] from BMX [illegible] box (4 [illegible] 32 channels)

[illegible]CAL JUNCTION BOX

[illegible]

GAUGE PLUGS (4 PIN)

[illegible]

[illegible]URFACE MOUNT TRANSDUCERS (HARD ROCK)

[illegible] velocity output [illegible] for rapid installation [illegible]

SURFACE MOUNT TRANSDUCERS (SOFT SOIL)

Recoverable triaxial [illegible] low frequency [illegible] into shallow 75mm augered hole

[illegible]ULLY COUPLED TRANSDUCERS

Non-recoverable for grouting at depth in holes. Singles, dual [illegible] triaxial elements with either accelerometers or geophones [illegible] specified [illegible] field use

[illegible]ICROPHONES

[illegible]

[illegible]MATHPACK MANUALS

[illegible]

[illegible]IVE CASE FOR BMX

[illegible]

DISK HEAD-CLEANING KIT

[illegible]

[illegible]ATTERY PACKS FOR T1200

[illegible]

[illegible]RINTER[illegible]

[illegible]

BLASTRONICS

[illegible]

APPENDIX E

Results from BMX Blast Monitor

Table E 1

Summary of BMX Blast Monitor recordings.

FILE/ DATE/ TIME	Max/Min Velocities (mm/s)			Logged by:	Dist to source (m)	Remarks
	Vertical (Vert)	Longitudinal (Horiz1)	Transverse (Horiz2)			
LING01	+28.0/-28.2	+14.0/-14.1	Quiet	RKB/ GRC	N.A.	Lab test - shaking the geophones. Signals clipped on Vert & Horiz1. Horiz2 test gain too low to register or no contact.
LING02	+28.0/-28.2	+14.0/-14.1	Some small spikes	RKB/ GRC	N.A.	Lab test - shaking the geophones. Signals clipped on Vert & Horiz1. Horiz2 test gain too low to register or no contact.
LING03/ 09-04-91/ 06:47	+28.0/-28.2	+12.9/-14.1	+22.5/-27.3	RKB/ GRC	7.9	12 East Top Level. Morning breaking blast in stone. Test to see appropriate amplification level for the three geophone channels (14.1 mm/s selected). Not possible to see individual delay groups. No microseismic activity evident within 6 second window after blast.
LING04/ 09-04-91	+2.3/-0.6	+3.5/-0.9	+2.1/-1.4	RKB/ GRC	N.A.	BMX Test recording.
LING05/ 09-04-91/ 15:15	+14.0/-14.1	+14.0/-14.1	+14.0/-14.1	RKB/ GRC	6.1	12 East Top Level. Afternoon breaking blast in stone. Not possible to see individual delay groups. No microseismic activity evident within 6 second window after blast.
LING06/ 09-04-91/ 15:42	+14.0/-14.1	+14.0/-14.1	+14.0/-14.1	RKB/ GRC	5.0	12 East Bottom Level. Afternoon breaking blast in stone. Slight scatter in groups, especially early groups. No unusual signals follow blast. Rock is quiet after blast - no unusual signals. No microseismic activity evident within 6 second time window after blast.
LING07/ 09-10-91	+14.0/-14.1	+14.0/-14.1	+14.0/-14.1	GRC	5.0	Lab test of BMX unit by CBCRL.

13EB1/ 09-17-91/ 10:40	Quiet	Quiet	Quiet	GRC/ CJB	5.0	13 East Bottom Level. Intersection development round. Round misfired due to bad cap - not recorded.
13EB2/ 09-19-91/ 06:35	+14.0/-6.3	+8.5/-5.5	+12.3/-9.0	GRC/ DAY	14.0	Some decaying vibrations follow blast, but no unusual microseismic signals noted. No unusual microseismic activity evident within 6 second time window after blast.
13EB3/ 09-23-91/ 17:51	Quiet	Quiet	Quiet	GRC/ JC	16.0	13 East Bottom Level. First shot in coal for intersection development round. Event not recorded due to equipment malfunction (disk controller error).
13EB4/ 09-23-91/ 17:54	+11.8/-5.3	+6.6/-5.9	+9.6/-0.0	GRC/ JC	16.0	13 East Bottom Level. Second shot in stone for intersection development round. Slight scatter in groups, but very clear four group initiation pattern. No microseismic activity evident within 6 second time window after blast.
13EB5/ 09-24-91/ 19:01	+7.3/-2.1	+7.7/-5.3	+6.4/-4.3	GRC	21.0	13 East Bottom Level. 13 Holes spread in stone and coal. Some scatter in groups, but probably no overlap. Some decaying vibrations follow blast, but no microseismic activity evident within 6 second time window after blast.
13EB6/ 09-25-91/ 18:26	+3.3/-0.6	+3.7/-2.5	+2.5/-2.9	GRC/ SR	25.0	Coal shot only. Very small vertical signal indicating decoupling in the vertical direction (due to open bedding planes?). Slight scatter in groups. Initiation pattern not very clear. No unusual microseismic signals evident within 6 second time window after blast.
13EB7/ 09-25-91/ 18:50	+10.5/-8.9	+4.4/-3.0	+3.3/-3.6	GRC/ SR	25.0	13 East Bottom Level. Shot in stone. Good record from a diagnostics viewpoint. Slight scatter in groups, but reasonably clear initiation pattern. Group @ #5 delay has very strong signal in vertical component. Group @ #6 delay is later than expected. No unusual microseismic signals evident within 6 second time window after blast.
TESTUG02/ 11-18-91/ 17:49	Quiet	Negligible	+0.4/+0.1	RKB/ GRC	3.0	13 East Wall Drive. Test conducted by recording a hammer tapping the ribside in the stone.
TESTUG03/ 11-18-91/ 17:58	Quiet	Negligible	+0.4/+0.2	RKB/ GRC	3.0	13 East Wall Drive. Test conducted by recording a hammer tapping the ribside in the stone.

TESTUG04/ 11-18-91/ 19:03	Overrange	Overrange	Overrange	RKB/ GRC	3.0	First test to try to record the Alpine mining. All channels recorded overrange. Possible electrical connection fault. All connections redone to eliminate the problem (successfully).
TESTUG05/ 11-18-91/ 19:07	Quiet	+2.0/-0.2	+0.8/-0.6	RKB/ GRC	3.0	Mining with the Voest-Alpine, cutting stone in the roof. Good record of the typical Alpine noise characteristics. Both the longitudinal and the transverse records show a good signal, characteristic of the cutting action of the Alpine miner. The maximum amplitude component occurs at a frequency of 400 Hz, indicative that this is the likely impact frequency of the individual picks on the cutting head at that particular time.
TESTUG06/ 11-18-91/ 19:10	+0.7/+0.7	+0.9/+0.8	+0.1/+0.0	RKB/ GRC	3.0	No mining during test - cutting stopped as record started.
TESTUG07/ 11-18-91/ 19:1[illegible]	Quiet	+1.3/+0.1	+0.8/-0.6	RKB/ GRC	3.0	Recording of typical mining with the Voest-Alpine. Alpine cutting stone in the roof. Both the longitudinal and the transverse records show a good signal, characteristic of the cutting action of the Alpine miner. The maximum amplitude component occurs at a frequency of 250 Hz, indicative that this is the likely impact frequency of the individual picks on the cutting head at that particular time.
TESTUG08/ 11-18-91/ 19:22	Quiet	+1.1/+0.3	+0.2/-0.1	RKB/ GRC	3.0	Recording of typical mining with Voest-Alpine, cutting coal in the floor. Good record of the typical Alpine noise characteristics.
TESTUG09/ 11-18-91/ 19:28	Negligible	Negligible	Negligible	RKB/ GRC	3.0	Weak signal due to coal. Strongest component at frequency of about 16 Hz. No microseismic activity evident within the time window of active cutting recorded.
TESTUG10/ 11-18-91/ 19:33	Negligible	Negligible	Negligible	RKB/ GRC	3.0	Weak signal due to coal. Strongest component at frequency of about 20 Hz. No microseismic activity evident within the time window of active cutting recorded.

BLAST RECORD: LING03

Blast data:

Date of test: September 4, 1991.
Time of test: 06:47
Rock type: Lingan sandstone above seam - early morning brushing blast @ 12 East Top Level.

Layout: See Figure E1
Hole Depth: 2.0 m
Distance to geophones: 7.9 m
No of charged holes: 12
Hole diameter: 38 mm
Explosive type: ICI Penobel Two (32 mm by 400 mm, 200 g)
Cap type: CXA
No of delays: 3x#1+2x#2+2x#3+2x#4+3x#5
Theoretical blast duration: 0.10 seconds (4 x 0.025 seconds)

Recorded parameters:

Horizontal Scales:
Time Scale (upper): 0.0454 s/mm
Time Scale (lower): 0.0028 s/mm

Vertical Scales:
Velocity Scale (V): 28.2 mm/s FSD
Velocity Scale (H1): 14.1 mm/s FSD
Velocity Scale (H2): 56.4 mm/s FSD

Measured Velocities:
PPV (Vertical): >28.2 mm/s
PPV (Horiz1-EW): >14.1 mm/s
PPV (Horiz2-NS): 27.3 mm/s

Measured blast duration: ± 0.15 seconds (including coda)

Interpretation: It is not possible to see the individual delay groups. This could be due to scatter of firing times of the delays or some simultaneous detonation could have occurred. Total blast signal duration slightly longer than theoretical duration as expected. No unusual signals follow blast.

Comments: Rock is quiet after blast - no unusual signals. Conclude that no microseismic activity occurred within 6 second time window after blast.

BLAST RECORD: LING04

Blast data:

Date of test: September 4, 1991.
Time of test: N.A.
Rock type: N.A. (BMX Test for 14.1 mm/s ranges.)

Layout: N.A.
Hole Depth: N.A.
Distance to geophones: N.A.
No of charged holes: N.A.
Hole diameter: N.A.
Explosive type: N.A.
Cap type: N.A.
No of delays: N.A.
Theoretical blast duration: N.A.

Recorded parameters:

Horizontal Scales:
Time Scale (upper): 0.0454 s/mm
Time Scale (lower): 0.0028 s/mm

Vertical Scales:
Velocity Scale (V): 14.1 mm/s FSD
Velocity Scale (H1): 14.1 mm/s FSD
Velocity Scale (H2): 14.1 mm/s FSD

Measured Velocities:
PPV (Vertical): 2.3 mm/s
PPV (Horiz1-EW): 3.5 mm/s
PPV (Horiz2-NS): 2.1 mm/s

Measured blast duration: ± 0.06 seconds (including coda)

Interpretation: Small signal recorded. Amplifier ranges working OK.

Comments: BMX Test only.

BLAST RECORD: LING05

Blast data:

Date of test:	September 4, 1991.
Time of test:	15:15
Rock type:	Lingan sandstone above seam - brushing blast. Same layout as LING03 @ 12 East Top Level.
Layout:	See Figure E2
Hole Depth:	2.0 m
Distance to geophones:	6.1 m
No of charged holes:	12
Hole diameter:	38 mm
Explosive type:	ICI Penobel Two (32 mm by 400 mm, 200 g)
Cap type:	CXA
No of delays:	3x#1+2x#2+2x#3+2x#4+3x#5
Theoretical blast duration:	0.10 seconds (4 x 0.025 seconds)

Recorded parameters:

Horizontal Scales:	
Time Scale (upper):	0.0454 s/mm
Time Scale (lower):	0.0028 s/mm
Vertical Scales:	
Velocity Scale (V):	14.1 mm/s FSD
Velocity Scale (H1):	14.1 mm/s FSD
Velocity Scale (H2):	14.1 mm/s FSD
Measured Velocities:	
PPV (Vertical):	> 14.1 mm/s
PPV (Horiz1-EW):	> 14.1 mm/s
PPV (Horiz2-NS):	> 14.1 mm/s
Measured blast duration:	± 0.15 seconds (including coda)
Interpretation:	It is not possible to see the individual delay groups. This could be due to scatter of firing times of the delays or some simultaneous detonation could have occurred. Total blast signal duration slightly longer than theoretical duration as expected. No unusual signals follow blast.
Comments:	Very similar to LING03. Rock is quiet after blast - no unusual signals. Conclude that no microseismic activity occurred within 6 second time window after blast.

BLAST RECORD: LING06

Blast data:

Date of test: September 4, 1991.
Time of test: 15:42
Rock type: Lingan sandstone above seam - afternoon brushing blast @ 12 East Bottom Level.

Layout: See Figure E3
Hole Depth: 2.0 m
Distance to geophones: 5.0 m
No of charged holes: 12
Hole diameter: 38 mm
Explosive type: ICI Penobel Two (32 mm by 400 mm, 200 g)
Cap type: CXA
No of delays: 3x#1+2x#2+4x#3+3x#6
Theoretical blast duration: 0.125 seconds (5 x 0.025 seconds)

Recorded parameters:

Horizontal Scales:
Time Scale (upper): 0.0454 s/mm
Time Scale (lower): 0.0014 s/mm

Vertical Scales:
Velocity Scale (V): 14.1 mm/s FSD
Velocity Scale (H1): 14.1 mm/s FSD
Velocity Scale (H2): 14.1 mm/s FSD

Measured Velocities:
PPV (Vertical): >14.1 mm/s
PPV (Horiz1-EW): >14.1 mm/s
PPV (Horiz2-NS): >14.1 mm/s

Measured blast duration: ± 0.18 seconds (including coda)

Interpretation: Delays #1, #2, #3 and #6 all clearly visible. Blast fired as planned. Slight scatter in groups, especially early groups. No unusual signals follow blast.

Comments: Rock is quiet after blast - no unusual signals. Conclude that no microseismic activity occurred within 6 second time window after blast.

BLAST RECORD: LING07

Blast data:

Date of test: September 10, 1991.
Time of test:
Rock type: Test of BMX by CBCRL Staff?

Layout: N.A.
Hole Depth: N.A.
Distance to geophones: N.A.
No of charged holes: N.A.
Hole diameter: N.A.
Explosive type: N.A.
Cap type: N.A.
No of delays: N.A.
Theoretical blast duration: N.A.

Recorded parameters:

Horizontal Scales:
Time Scale (upper): 0.0454 s/mm
Time Scale (lower): 0.0014 s/mm

Vertical Scales:
Velocity Scale (V): 14.1 mm/s FSD
Velocity Scale (H1): 14.1 mm/s FSD
Velocity Scale (H2): 14.1 mm/s FSD

Measured Velocities:
PPV (Vertical): > 14.1 mm/s
PPV (Horiz1-EW): > 14.1 mm/s
PPV (Horiz2-NS): > 14.1 mm/s

Measured blast duration: ± seconds (including coda)

Interpretation: Bumping the triaxial setup by hand in laboratory.

Comments: Test of BMX?

BLAST RECORD: 13EB1

Blast data:

Date of test:	September 17, 1991.
Time of test:	10:40
Rock type:	Lingan coal seam.
Layout:	Four 4 ft holes in coal to start updip mining.
Hole Depth:	1.22 m
Distance to geophones:	5.0 m
No of charged holes:	4
Hole diameter:	38 mm
Explosive type:	ICI Penobel Two (32 mm by 400 mm, 200 g)
Cap type:	CXA
No of delays:	2x#1+2x#2
Theoretical blast duration:	0.025 seconds (1 x 0.025 seconds)

Recorded parameters:

Horizontal Scales:	
Time Scale (upper):	0.0454 s/mm
Time Scale (lower):	0.0014 s/mm
Vertical Scales:	
Velocity Scale (V):	14.1 mm/s FSD
Velocity Scale (H1):	14.1 mm/s FSD
Velocity Scale (H2):	14.1 mm/s FSD
Measured Velocities:	
PPV (Vertical):	0.0 mm/s
PPV (Horiz1-EW):	0.0 mm/s
PPV (Horiz2-NS):	0.0 mm/s
Measured blast duration:	± 0.0 seconds

Interpretation:	Nothing recorded. Misfire? No unusual signals recorded.
Comments:	Round misfired due to a bad cap. No microseismic or other activity recorded within 6.5 second time window.

BLAST RECORD: 13EB2

Blast data:

Date of test: September 19, 1991.
Time of test: 06:35
Rock type: Lingan seam and roof sandstone.

Layout: See Figure E4
Hole Depth: 1.22 m.
Distance to geophones: ± 14 m.
No of charged holes: 4.
Hole diameter: 38 mm.
Explosive type: ICI Penobel Two (32 mm by 400 mm, 200 g)
Cap type: CXA.
No of delays: 4x#1.
Theoretical blast duration: Scatter only - 1 Delay.

Recorded parameters:

Horizontal Scales:
Time Scale (upper): 0.0454 s/mm
Time Scale (lower): 0.0014 s/mm

Vertical Scales:
Velocity Scale (V): 14.1 mm/s FSD
Velocity Scale (H1): 14.1 mm/s FSD
Velocity Scale (H2): 14.1 mm/s FSD

Measured Velocities:
PPV (Vertical): >14.1 mm/s
PPV (Horiz1-EW): 8.5 mm/s
PPV (Horiz2-NS): 12.3 mm/s

Measured blast duration: ± 0.07 seconds (including coda)

Interpretation: Slight scatter in group. Some decaying vibrations follow blast, but no unusual microseismic signals follow blast.

Comments: Rock is quiet after blast - no unusual signals. Conclude that no microseismic activity occurred within 6 second time window after blast.

BLAST RECORD: 13EB3

Blast data:

Date of test:	September 23, 1991.
Time of test:	17:51
Rock type:	Lingan coal seam.
Layout:	Figure E5
Hole Depth:	1.22 m.
Distance to geophones:	± 16 m.
No of charged holes:	15.
Hole diameter:	38 mm.
Explosive type:	ICI Penobel Two (32 mm by 400 mm, 200 g)
Cap type:	CXA.
No of delays:	3x#1+2x#2+5x#3+5x#4.
Theoretical blast duration:	0.075 seconds (3 x 0.025 seconds).

Recorded parameters:

Horizontal Scales:	
Time Scale (upper):	0.0454 s/mm
Time Scale (lower):	0.0028 s/mm
Vertical Scales:	
Velocity Scale (V):	14.1 mm/s FSD
Velocity Scale (H1):	14.1 mm/s FSD
Velocity Scale (H2):	14.1 mm/s FSD
Measured Velocities:	
PPV (Vertical):	N.R.
PPV (Horiz1-EW):	N.R.
PPV (Horiz2-NS):	N.R.
Measured blast duration:	N.R.
Interpretation:	Not recorded due to equipment malfunction.
Comments:	N.A.

BLAST RECORD: 13EB4

Blast data:

Date of test:	September 23, 1991.
Time of test:	17:54
Rock type:	Lingan roof sandstone.
Layout:	Figure E6
Hole Depth:	1.22 m.
Distance to geophones:	± 16 m.
No of charged holes:	15.
Hole diameter:	38 mm.
Explosive type:	ICI Powergel Two (32 mm by 400 mm, 200 g)
Cap type:	CXA.
No of delays:	6x#1 + 3x#5 + 2x#6 + 4x#7
Theoretical blast duration:	0.15 seconds (6 x 0.025 seconds).

Recorded parameters:

Horizontal Scales:	
Time Scale (upper):	0.0454 s/mm
Time Scale (lower):	0.0028 s/mm
Vertical Scales:	
Velocity Scale (V):	14.1 mm/s FSD
Velocity Scale (H1):	14.1 mm/s FSD
Velocity Scale (H2):	14.1 mm/s FSD
Measured Velocities:	
PPV (Vertical):	11.8 mm/s
PPV (Horiz1-EW):	6.6 mm/s
PPV (Horiz2-NS):	9.0 mm/s
Measured blast duration:	± 0.175 seconds (including short coda)

Interpretation:	Slight scatter in groups, but very clear four group initiation pattern. No unusual microseismic signals follow blast.
Comments:	Unusual timing sequence? Rock is quiet after blast - no unusual signals apart from slight electrical noise. Conclude that no microseismic activity occurred within 6 second time window after blast.

BLAST RECORD: 13EB5

Blast data:

Date of test: September 24, 1991.
Time of test: 19:01
Rock type: Lingan seam and roof sandstone.

Layout: Figure E7
Hole Depth: 1.22 m.
Distance to geophones: ± 21 m.
No of charged holes: 14.
Hole diameter: 38 mm.
Explosive type: ICI Penobel Two (32 mm by 400 mm, 200 g)
Cap type: CXA.
No of delays: 6x#1+2x#2+6x#3.
Theoretical blast duration: 0.05 seconds (2 x 0.025 seconds).

Recorded parameters:

Horizontal Scales:
Time Scale (upper): 0.0454 s/mm
Time Scale (lower): 0.0014 s/mm

Vertical Scales:
Velocity Scale (V): 14.1 mm/s FSD
Velocity Scale (H1): 14.1 mm/s FSD
Velocity Scale (H2): 14.1 mm/s FSD

Measured Velocities:
PPV (Vertical): 7.3 mm/s
PPV (Horiz1-EW): 7.7 mm/s
PPV (Horiz2-NS): 6.4 mm/s

Measured blast duration: ± 0.10 seconds (including small coda)

Interpretation: Fair scatter in groups, but probably no overlap. Some decaying vibrations follow blast, but no unusual microseismic signals follow blast.

Comments: Rock is quiet after blast - no unusual signals. Conclude that no microseismic activity occurred within 6 second time window after blast.

BLAST RECORD: 13EB6

Blast data:

Date of test:	September 25, 1991.
Time of test:	18:26
Rock type:	Lingan coal seam.
Layout:	Figure E8
Hole Depth:	1.22 m.
Distance to geophones:	± 25 m.
No of charged holes:	16.
Hole diameter:	38 mm.
Explosive type:	ICI Penobel Two (32 mm by 400 mm, 200 g)
Cap type:	CXA.
No of delays:	9x#1 + 3x#2 + 1x#3 + 3x#4.
Theoretical blast duration:	0.075 seconds (3 x 0.025 seconds).

Recorded parameters:

Horizontal Scales:	
Time Scale (upper):	0.0454 s/mm
Time Scale (lower):	0.0014 s/mm
Vertical Scales:	
Velocity Scale (V):	14.1 mm/s FSD
Velocity Scale (H1):	14.1 mm/s FSD
Velocity Scale (H2):	14.1 mm/s FSD
Measured Velocities:	
PPV (Vertical):	3.3 mm/s.
PPV (Horiz1-EW):	3.7 mm/s.
PPV (Horiz2-NS):	2.9 mm/s.
Measured blast duration:	0.10 seconds.
Interpretation:	Slight scatter in groups. Initiation pattern not very clear. No unusual microseismic signals follow blast. Blast is getting too far from geophone array.
Comments:	Rock is quiet after blast - no unusual signals apart from slight electrical noise. Conclude that no microseismic activity occurred within 6 second time window after blast.

BLAST RECORD: 13EB7

Blast data:

Date of test:	September 25, 1991.
Time of test:	18:50
Rock type:	Lingan roof sandstone.

Layout:	Figure E9
Hole Depth:	1.22 m.
Distance to geophones:	± 25 m.
No of charged holes:	16.
Hole diameter:	38 mm.
Explosive type:	ICI Penobel Two (32 mm by 400 mm, 200 g).
Cap type:	CXA.
No of delays:	1x#1 + 2x#2 + 2x#3 + 1x#4 + 5x#5 + 5x#6
Theoretical blast duration:	0.15 seconds (6 x 0.025 seconds).

Recorded parameters:

Horizontal Scales:	
Time Scale (upper):	0.0454 s/mm
Time Scale (lower):	0.0028 s/mm

Vertical Scales:	
Velocity Scale (V):	14.1 mm/s FSD
Velocity Scale (H1):	14.1 mm/s FSD
Velocity Scale (H2):	14.1 mm/s FSD

Measured Velocities:	
PPV (Vertical):	10.5 mm/s
PPV (Horiz1-EW):	4.4 mm/s
PPV (Horiz2-NS):	3.6 mm/s

Measured blast duration:	± 0.150 seconds (including short coda)

Interpretation:	Slight scatter in groups, but reasonably clear initiation pattern. Group @ #5 delay has very strong signal in vertical component. Group @ #6 delay is later than expected. No unusual microseismic signals follow blast.

Comments:	Unusual timing sequence? Rock is quiet after blast - no unusual signals apart from slight electrical noise. Conclude that no microseismic activity occurred within 6 second time window after blast.

BLAST RECORD: TESTUG02

Blast data:

Date of test:	November 18, 1991.
Time of test:	17:49
Rock type:	Lingan roof sandstone.
Layout:	N.A.
Hole Depth:	N.A.
Distance to geophones:	± 3 m.
No of charged holes:	N.A.
Hole diameter:	N.A.
Explosive type:	N.A.
Cap type:	N.A.
No of delays:	N.A.
Theoretical blast duration:	N.A

Recorded parameters:

Horizontal Scales:	
Time Scale (upper):	0.0454 s/mm
Time Scale (lower):	0.0007 s/mm
Vertical Scales:	
Velocity Scale (V):	14.1 mm/s FSD
Velocity Scale (H1):	14.1 mm/s FSD
Velocity Scale (H2):	14.1 mm/s FSD
Measured Velocities:	
PPV (Vertical):	Quiet
PPV (Horiz1-EW):	Negligible
PPV (Horiz2-NS):	0.4 mm/s
Measured blast duration:	N.A.
Interpretation:	Hammer test for BMX operation. Good signals measured in E-W direction (same as hammer tap).
Comments:	System OK - no unusual seismic noise.

BLAST RECORD: TESTUG03

Blast data:

Date of test:	November 18, 1991.
Time of test:	17:58
Rock type:	Lingan roof sandstone.
Layout:	N.A.
Hole Depth:	N.A.
Distance to geophones:	± 3 m.
No of charged holes:	N.A.
Hole diameter:	N.A.
Explosive type:	N.A.
Cap type:	N.A.
No of delays:	N.A.
Theoretical blast duration:	N.A.

Recorded parameters:

Horizontal Scales:	
Time Scale (upper):	0.0454 s/mm
Time Scale (lower):	0.0007 s/mm
Vertical Scales:	
Velocity Scale (V):	14.1 mm/s FSD
Velocity Scale (H1):	14.1 mm/s FSD
Velocity Scale (H2):	14.1 mm/s FSD
Measured Velocities:	
PPV (Vertical):	Quiet
PPV (Horiz1-EW):	Negligible
PPV (Horiz2-NS):	0.4 mm/s
Measured blast duration:	N.A.

Interpretation:	Hammer test for BMX operation. Good signals measured in E-W direction (same as hammer tap).
Comments:	System OK - no unusual seismic noise.

BLAST RECORD: TESTUG04

Blast data:

Date of test: November 18, 1991.
Time of test: 19:03
Rock type: Lingan roof sandstone.

Layout: N.A.
Hole Depth: N.A.
Distance to geophones: ± 3 m.
No of charged holes: N.A.
Hole diameter: N.A.
Explosive type: N.A.
Cap type: N.A.
No of delays: N.A.
Theoretical blast duration: N.A.

Recorded parameters:

Horizontal Scales:
Time Scale (upper): 0.0454 s/mm
Time Scale (lower): 0.0007 s/mm

Vertical Scales:
Velocity Scale (V): 14.1 mm/s FSD
Velocity Scale (H1): 14.1 mm/s FSD
Velocity Scale (H2): 14.1 mm/s FSD

Measured Velocities:
PPV (Vertical): Out of range
PPV (Horiz1-EW): Out of range
PPV (Horiz2-NS): Out of range

Measured blast duration: N.A.

Interpretation: All signals underrange.

Comments: First attempt to record cutting with Alpine (unsuccessful). Electrical or computer fault?

BLAST RECORD: TESTUG05

Blast data:

Date of test:	November 18, 1991.
Time of test:	19:07
Rock type:	Lingan roof sandstone.

Layout:	N.A.
Hole Depth:	N.A.
Distance to geophones:	± 3 m.
No of charged holes:	N.A.
Hole diameter:	N.A.
Explosive type:	N.A.
Cap type:	N.A.
No of delays:	N.A.
Theoretical blast duration:	N.A.

Recorded parameters:

Horizontal Scales:	
Time Scale (upper):	0.0454 s/mm
Time Scale (lower):	0.00014 s/mm

Vertical Scales:	
Velocity Scale (V):	14.1 mm/s FSD
Velocity Scale (H1):	14.1 mm/s FSD
Velocity Scale (H2):	14.1 mm/s FSD

Measured Velocities:	
PPV (Vertical):	Negligible.
PPV (Horiz1-EW):	2.0 mm/s
PPV (Horiz2-NS):	0.8 mm/s

Measured blast duration:	N.A.

Interpretation:

Both the longitudinal and the transverse records show a good signal, characteristic of the cutting action of the Alpine miner. The maximum amplitude component occurs at a frequency of 400 Hz, indicative that this is the likely impact frequency of the individual picks on the cutting head at that particular time.

Comments:

Second attempt to record cutting with Alpine. During the test the sandstone was being cut by the miner, hence the strong signal.

BLAST RECORD: TESTUG06

Blast data:

Date of test: November 18, 1991.
Time of test: 19:10
Rock type: N.A.

Layout: N.A.
Hole Depth: N.A.
Distance to geophones: N.A.
No of charged holes: N.A.
Hole diameter: N.A.
Explosive type: N.A.
Cap type: N.A.
No of delays: N.A.
Theoretical blast duration: N.A.

Recorded parameters:

Horizontal Scales:
Time Scale (upper): 0.0454 s/mm
Time Scale (lower): 0.0056 s/mm

Vertical Scales:
Velocity Scale (V): 14.1 mm/s FSD
Velocity Scale (H1): 14.1 mm/s FSD
Velocity Scale (H2): 14.1 mm/s FSD

Measured Velocities:
PPV (Vertical): 0.7 mm/s
PPV (Horiz1-EW): 0.9 mm/s
PPV (Horiz2-NS): 0.1 mm/s

Measured blast duration: N.A.

Interpretation: BMX test.

Comments: BMX test.

BLAST RECORD: TESTUG07

Blast data:

Date of test:	November 18, 1991.
Time of test:	19:19
Rock type:	Lingan roof sandstone.
Layout:	N.A.
Hole Depth:	N.A.
Distance to geophones:	± 3 m.
No of charged holes:	N.A.
Hole diameter:	N.A.
Explosive type:	N.A.
Cap type:	N.A.
No of delays:	N.A.
Theoretical blast duration:	N.A.

Recorded parameters:

Horizontal Scales:	
Time Scale (upper):	0.0454 s/mm
Time Scale (lower):	0.00014 s/mm
Vertical Scales:	
Velocity Scale (V):	14.1 mm/s FSD
Velocity Scale (H1):	14.1 mm/s FSD
Velocity Scale (H2):	14.1 mm/s FSD
Measured Velocities:	
PPV (Vertical):	Negligible.
PPV (Horiz1-EW):	1.3 mm/s
PPV (Horiz2-NS):	0.8 mm/s
Measured blast duration:	N.A.

Interpretation: Both the longitudinal and the transverse records show a good signal, characteristic of the cutting action of the Alpine miner. The maximum amplitude component occurs at a frequency of 250 Hz, indicative that this is the likely impact frequency of the individual picks on the cutting head at that particular time.

Comments: Second attempt to record cutting with Alpine. During the test the sandstone was being cut by the miner, hence the strong signal.

BLAST RECORD: TESTUG08

Blast data:

Date of test:	November 18, 1991.
Time of test:	19:22
Rock type:	Lingan coal.
Layout:	N.A.
Hole Depth:	N.A.
Distance to geophones:	± 3 m.
No of charged holes:	N.A.
Hole diameter:	N.A.
Explosive type:	N.A.
Cap type:	N.A.
No of delays:	N.A.
Theoretical blast duration:	N.A.

Recorded parameters:

Horizontal Scales:	
Time Scale (upper):	0.0454 s/mm
Time Scale (lower):	0.00014 s/mm
Vertical Scales:	
Velocity Scale (V):	14.1 mm/s FSD
Velocity Scale (H1):	14.1 mm/s FSD
Velocity Scale (H2):	14.1 mm/s FSD
Measured Velocities:	
PPV (Vertical):	Negligible.
PPV (Horiz1-EW):	1.1 mm/s
PPV (Horiz2-NS):	0.2 mm/s
Measured blast duration:	N.A.

Interpretation: Both the longitudinal and the transverse records show a good signal, characteristic of the cutting action of the Alpine miner. The maximum amplitude component occurs at a frequency of 250 Hz, indicative that this is the likely impact frequency of the individual picks on the cutting head at that particular time.

Comments: Second attempt to record cutting with Alpine. During the test the sandstone was being cut by the miner, hence the strong signal.

BLAST RECORD: TESTUG09

Blast data:

Date of test: November 18, 1991.
Time of test: 19:28
Rock type: Lingan coal.

Layout: N.A.
Hole Depth: N.A.
Distance to geophones: ± 3 m.
No of charged holes: N.A.
Hole diameter: N.A.
Explosive type: N.A.
Cap type: N.A.
No of delays: N.A.
Theoretical blast duration: N.A.

Recorded parameters:

Horizontal Scales:
Time Scale (upper): 0.0454 s/mm
Time Scale (lower): 0.00014 s/mm

Vertical Scales:
Velocity Scale (V): 14.1 mm/s FSD
Velocity Scale (H1): 14.1 mm/s FSD
Velocity Scale (H2): 14.1 mm/s FSD

Measured Velocities:
PPV (Vertical): Negligible.
PPV (Horiz1-EW): Negligible.
PPV (Horiz2-NS): Negligible.

Measured blast duration: N.A.

Interpretation: Weak signal due to coal. Strongest component at frequency of about 16 Hz. No microseismic noise evident.

Comments: No microseismic activity evident within the time window of active cutting recorded.

BLAST RECORD: TESTUG10

Blast data:

Date of test: November 18, 1991.
Time of test: 19:33
Rock type: Lingan coal.

Layout: N.A.
Hole Depth: N.A.
Distance to geophones: ± 3 m.
No of charged holes: N.A.
Hole diameter: N.A.
Explosive type: N.A.
Cap type: N.A.
No of delays: N.A.
Theoretical blast duration: N.A.

Recorded parameters:

Horizontal Scales:
Time Scale (upper): 0.0454 s/mm
Time Scale (lower): 0.00014 s/mm

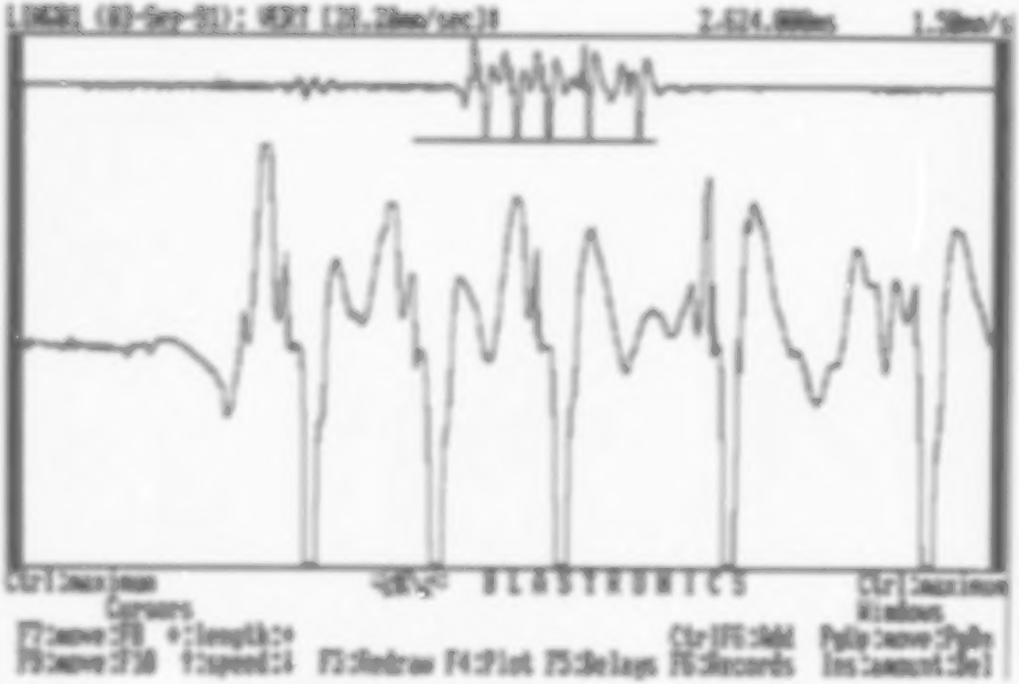
Vertical Scales:
Velocity Scale (V): 14.1 mm/s FSD
Velocity Scale (H1): 14.1 mm/s FSD
Velocity Scale (H2): 14.1 mm/s FSD

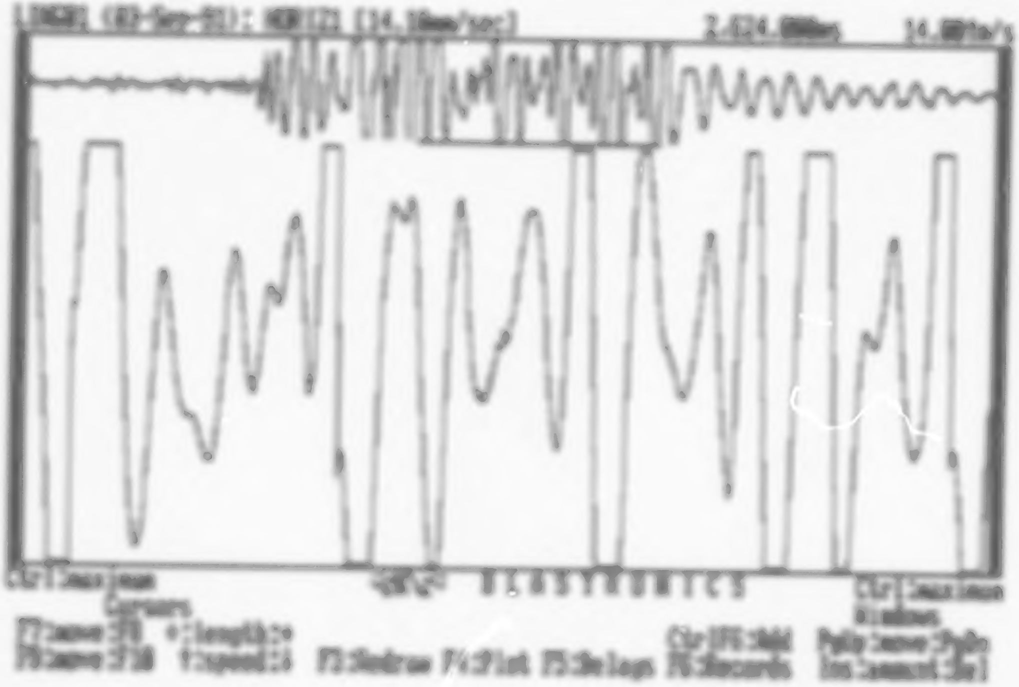
Measured Velocities:
PPV (Vertical): Negligible.
PPV (Horiz1-EW): Negligible.
PPV (Horiz2-NS): Negligible.

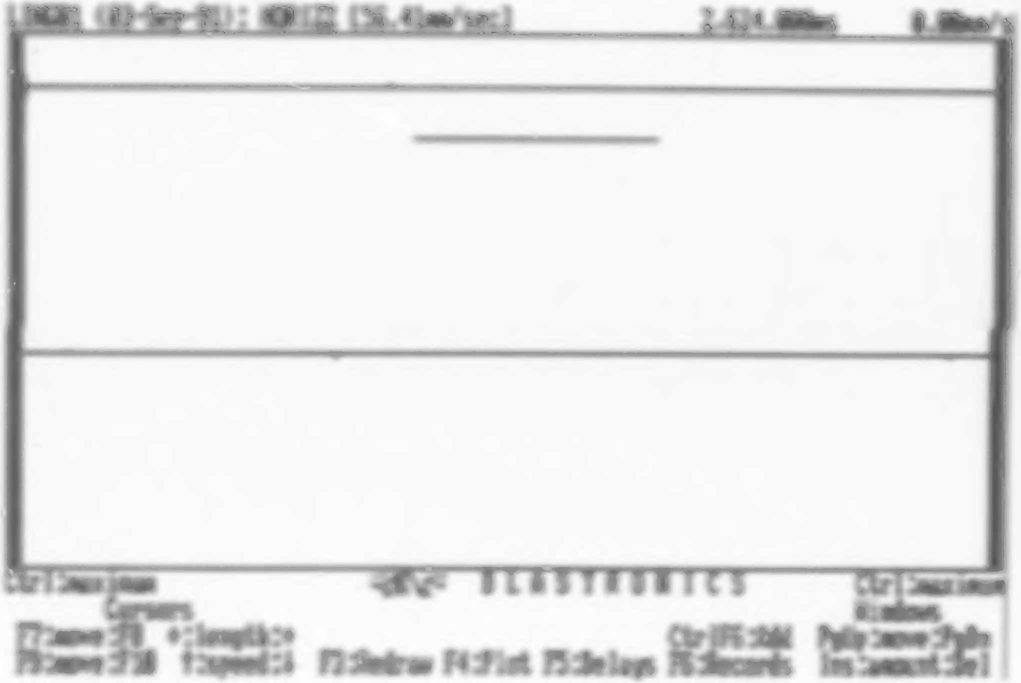
Measured blast duration: N.A.

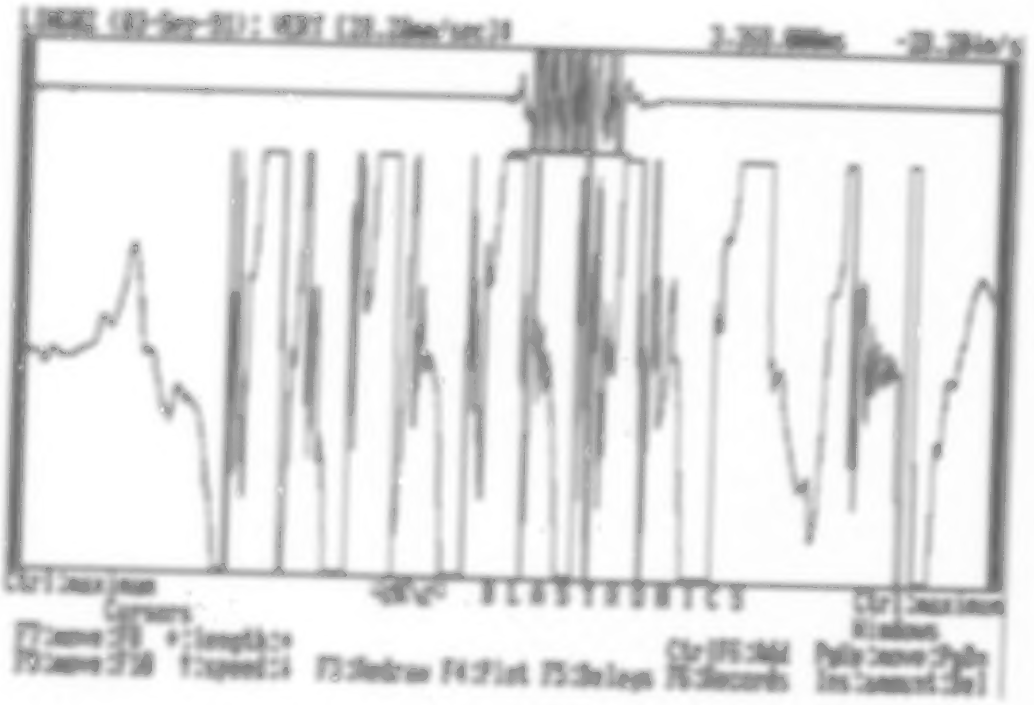
Interpretation: Weak signal due to coal. Strongest component at frequency of about 20 Hz. No microseismic noise evident.

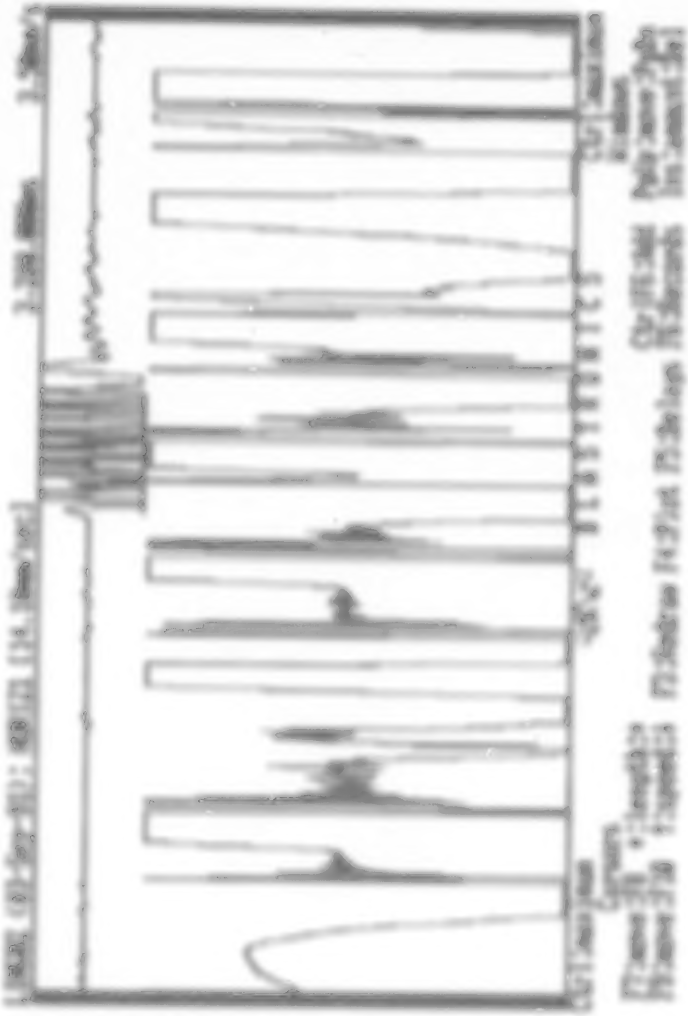
Comments: No microseismic activity evident within the time window of active cutting recorded.

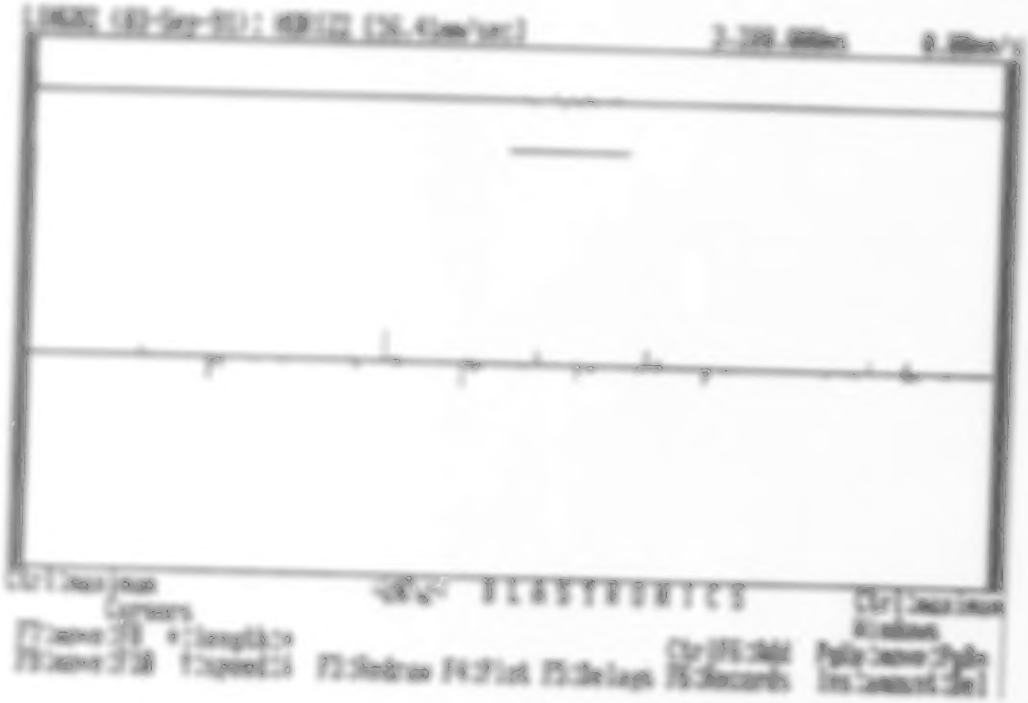

2,624.000ms
1.50mm/s
BLASTRONICS
Cursors
Windows
F3:Redraw F4:Plot F5:Delays F6:Records

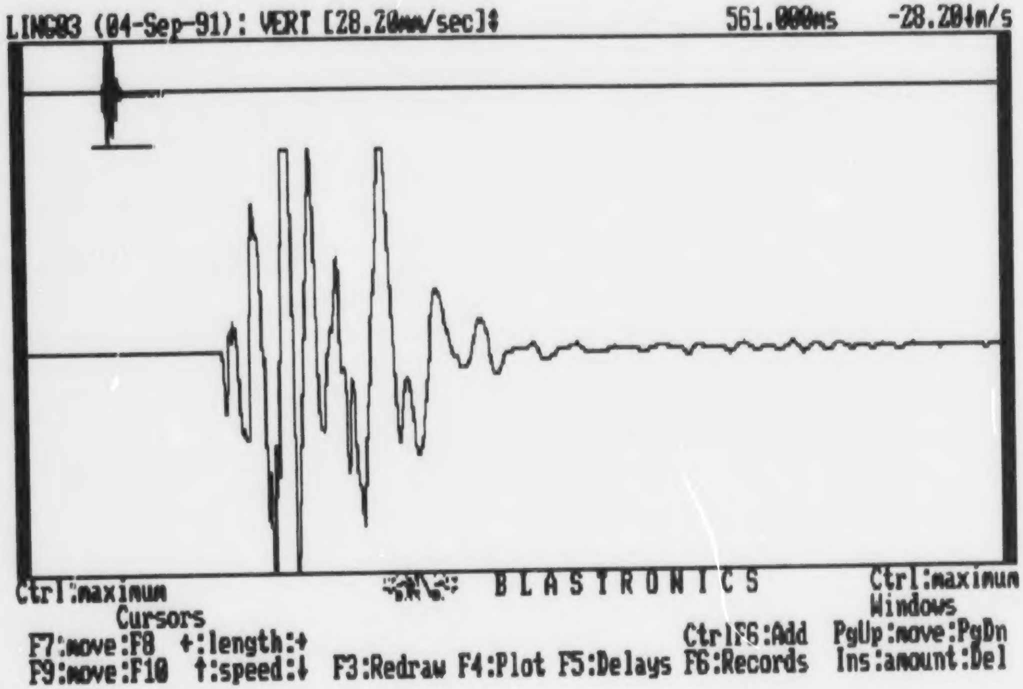

[14.10mm/sec]
2,024.000ms
B L A S T R O N I C S
Cursors
Windows
F3:Redraw F4:Plot F5:Delays F6:Records

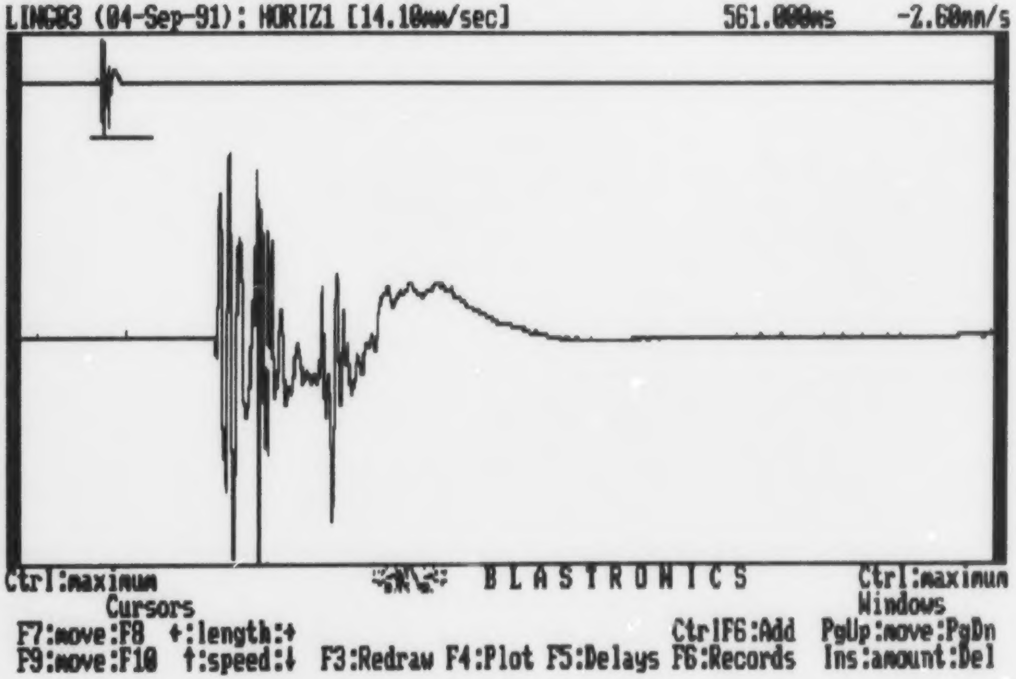

Cursors
Windows
F3:Redraw F4:Plot F5:Delays F6:Records



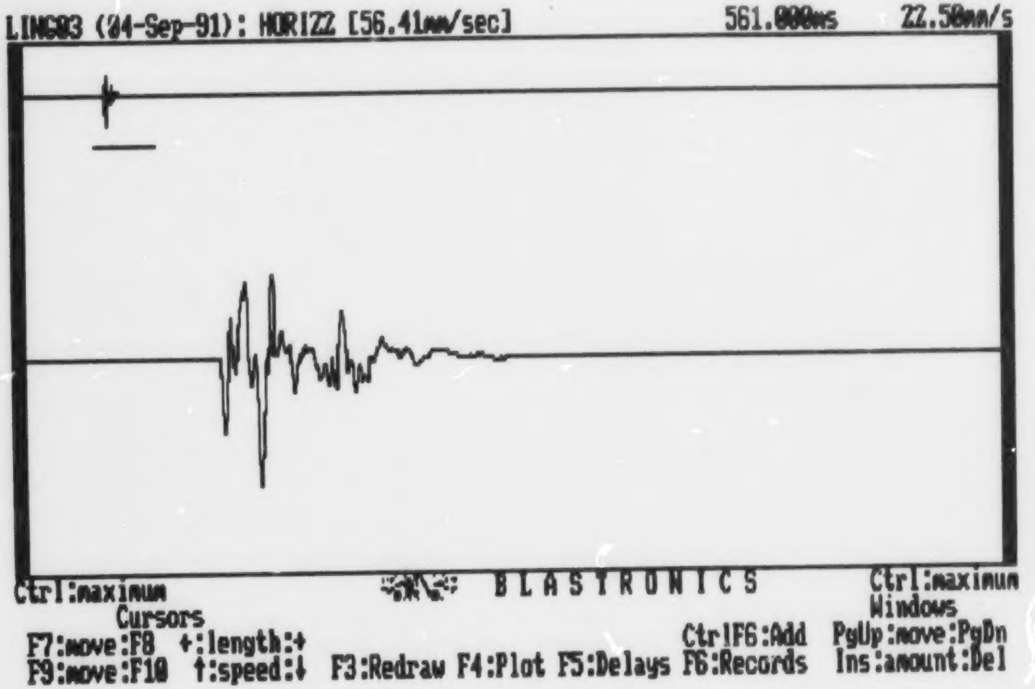


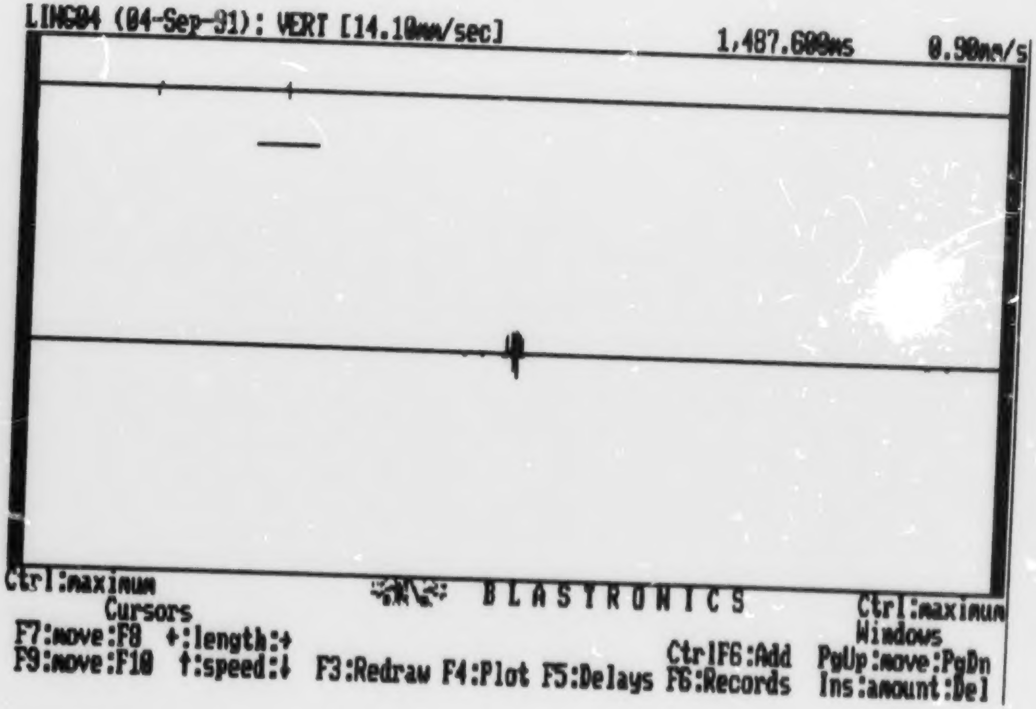

F3:Redraw
F4:Plot
F5:Delays


LIN003 (04-Sep-91): VERT [28.20mm/sec]↕
561.000ms
-28.20mm/s
BLASTRONICS
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del



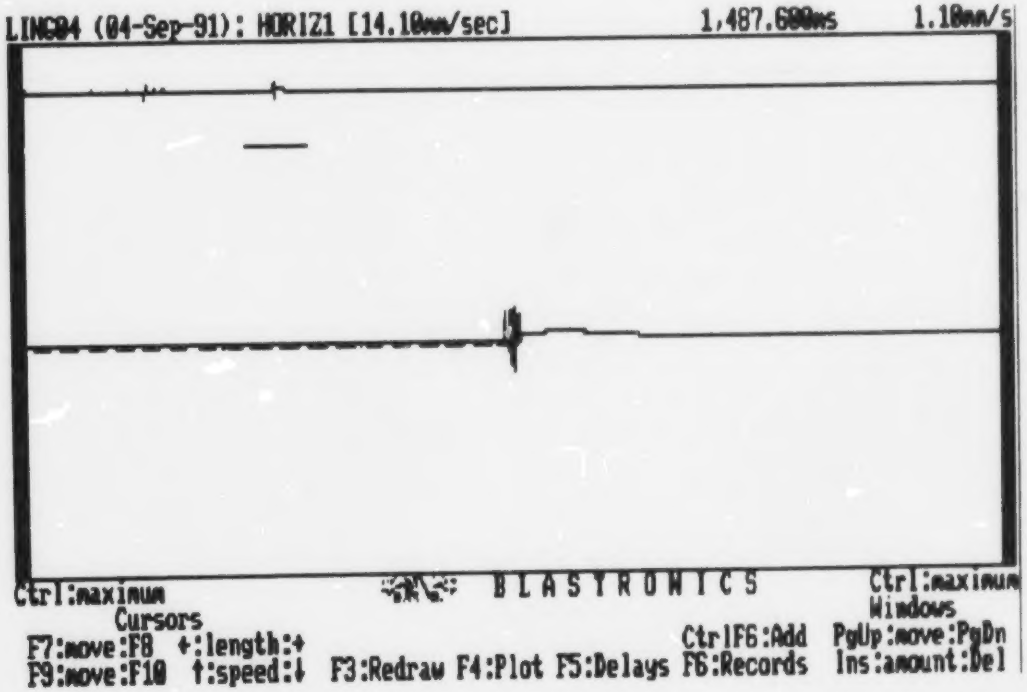
```
LING03 (04-Sep-91): HORIZ1 [14.10mm/sec]                   561.000ms     -2.60mm/s
Ctrl:maximum                        B L A S T R O N I C S           Ctrl:maximum
      Cursors                                                        Windows
F7:move:F8   ←:length:→                                  CtrlF6:Add  PgUp:move:PgDn
F9:move:F10  ↑:speed:↓   F3:Redraw F4:Plot F5:Delays F6:Records  Ins:amount:Del
```

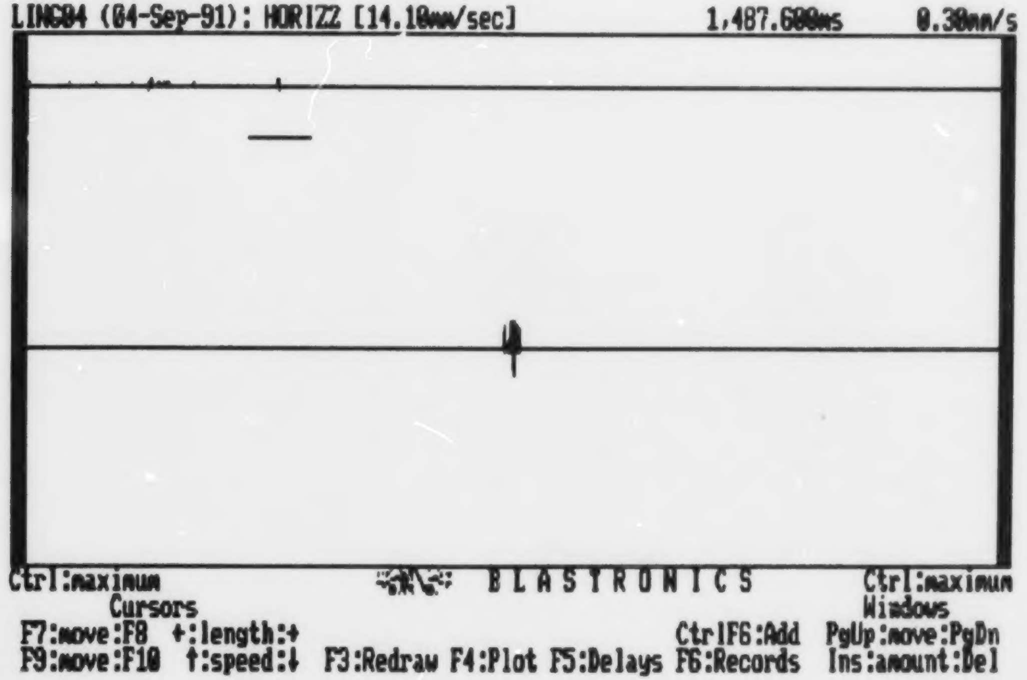

LING03 (04-Sep-91): HORIZZ [56.41mm/sec]
561.000ms
22.50mm/s
BLASTRONICS
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del



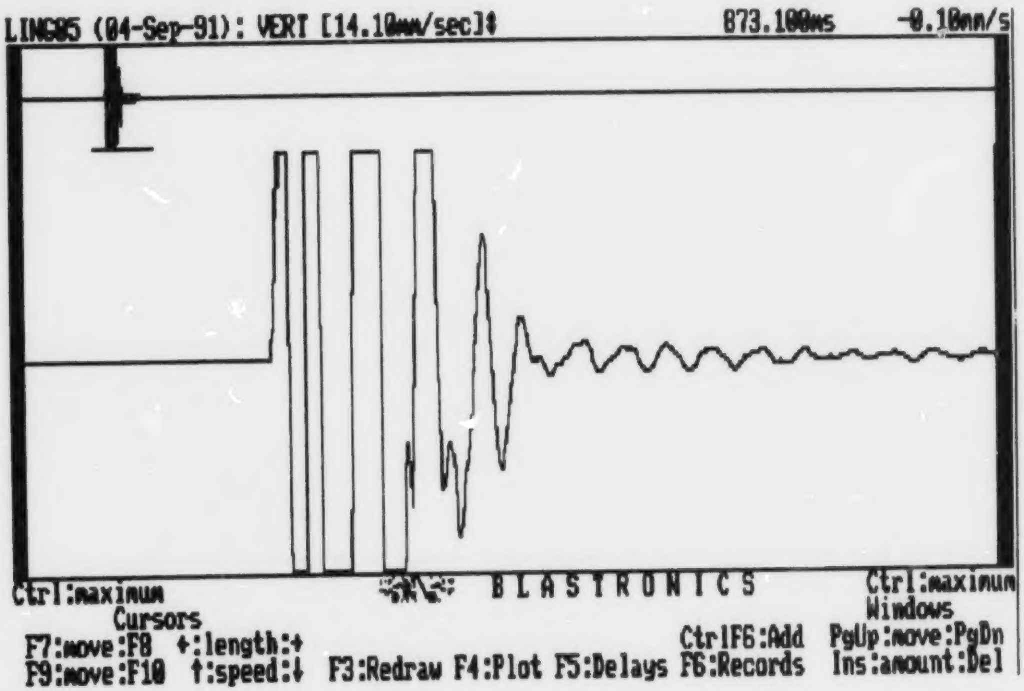
LING04 (04-Sep-91): VERT [14.10mm/sec] 1,487.600ms 0.90mm/s

Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
BLASTRONICS
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

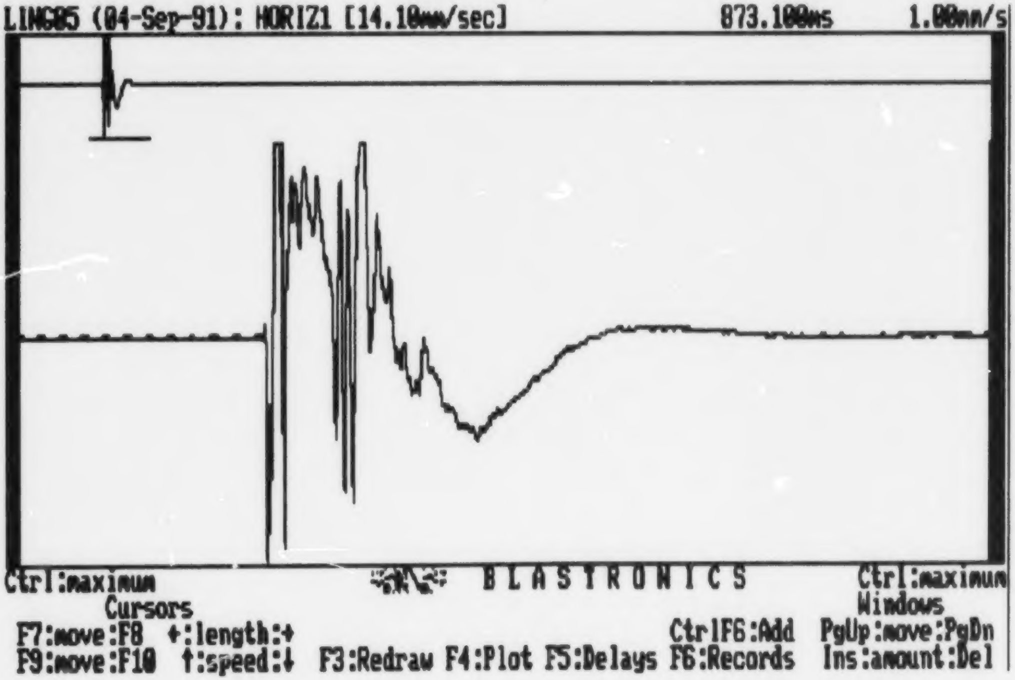

LING04 (04-Sep-91): HORIZ1 [14.10mm/sec]
1,487.600ms
1.10mm/s
BLASTRONICS
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del



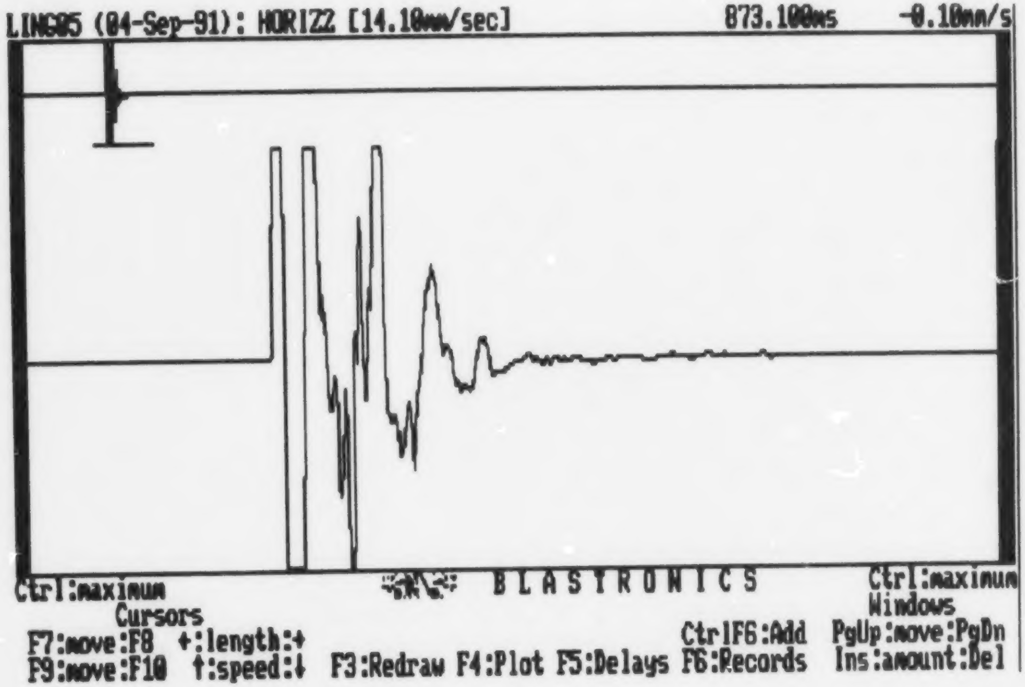
```
LING04 (04-Sep-91): HORIZZ [14.10mm/sec]               1,487.600ms     0.30mm/s

Ctrl:maximum                      BLASTRONICS                        Ctrl:maximum
      Cursors                                                         Windows
 F7:move:F8  +:length:+                               CtrlF6:Add  PgUp:move:PgDn
 F9:move:F10  ↑:speed:↓   F3:Redraw F4:Plot F5:Delays F6:Records  Ins:amount:Del
```

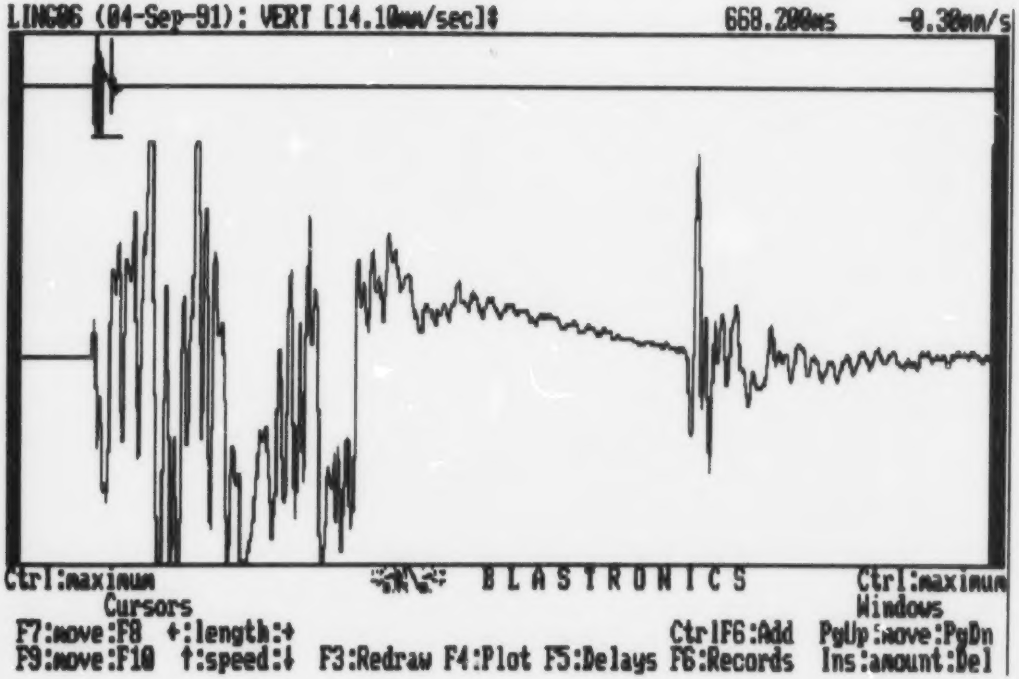


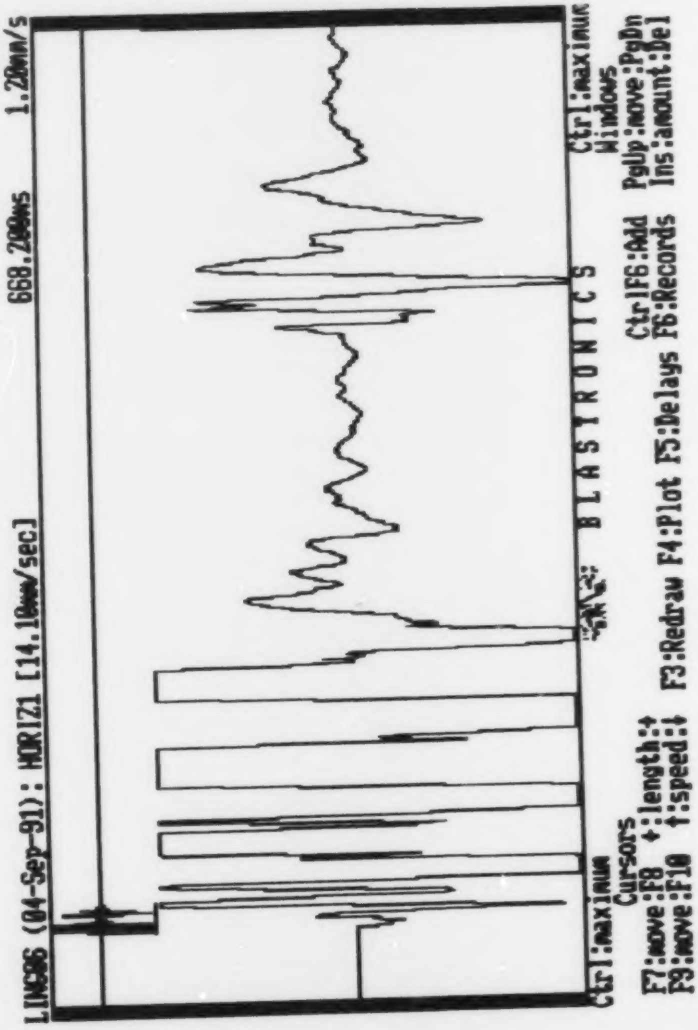
```
LING05 (04-Sep-91): VERT [14.10mm/sec]↕                873.100ms    -0.10mm/s
Ctrl:maximum                          B L A S T R O N I C S          Ctrl:maximum
        Cursors                                                       Windows
 F7:move:F8  ←:length:→                               CtrlF6:Add   PgUp:move:PgDn
 F9:move:F10  ↑:speed:↓  F3:Redraw F4:Plot F5:Delays F6:Records    Ins:amount:Del
```



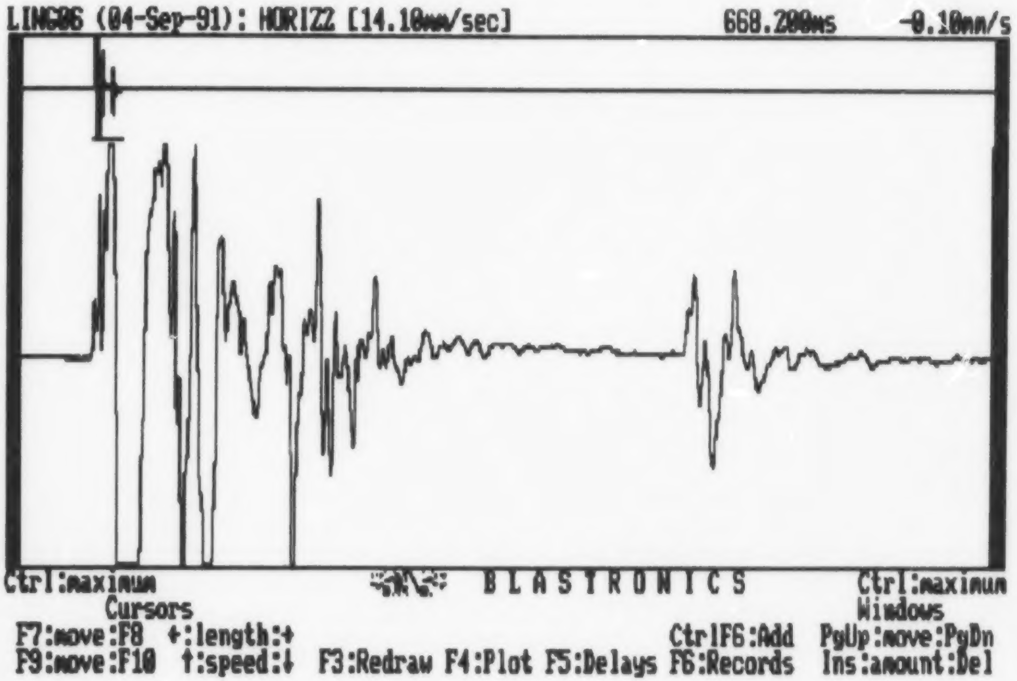
```
LING05 (04-Sep-91): HORIZ1 [14.10mm/sec]          873.100ms     1.00mm/s
Ctrl:maximum              B L A S T R O N I C S            Ctrl:maximum
    Cursors                                                 Windows
F7:move:F8  ←:length:→                       CtrlF6:Add  PgUp:move:PgDn
F9:move:F10  ↑:speed:↓  F3:Redraw F4:Plot F5:Delays F6:Records  Ins:amount:Del
```

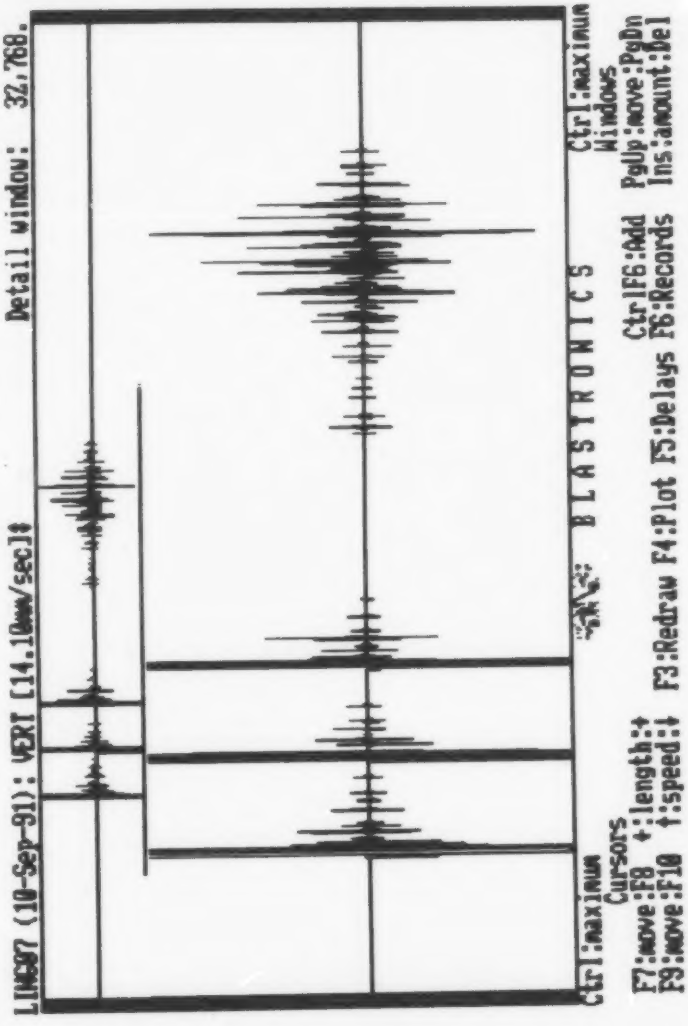

LING05 (04-Sep-91): HORIZ2 [14.10mm/sec]
873.100ms
-0.10mm/s
BLASTRONICS
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del


LING06 (04-Sep-91): VERT [14.10mm/sec]‡
668.200ms
-0.30mm/s
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
BLASTRONICS
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

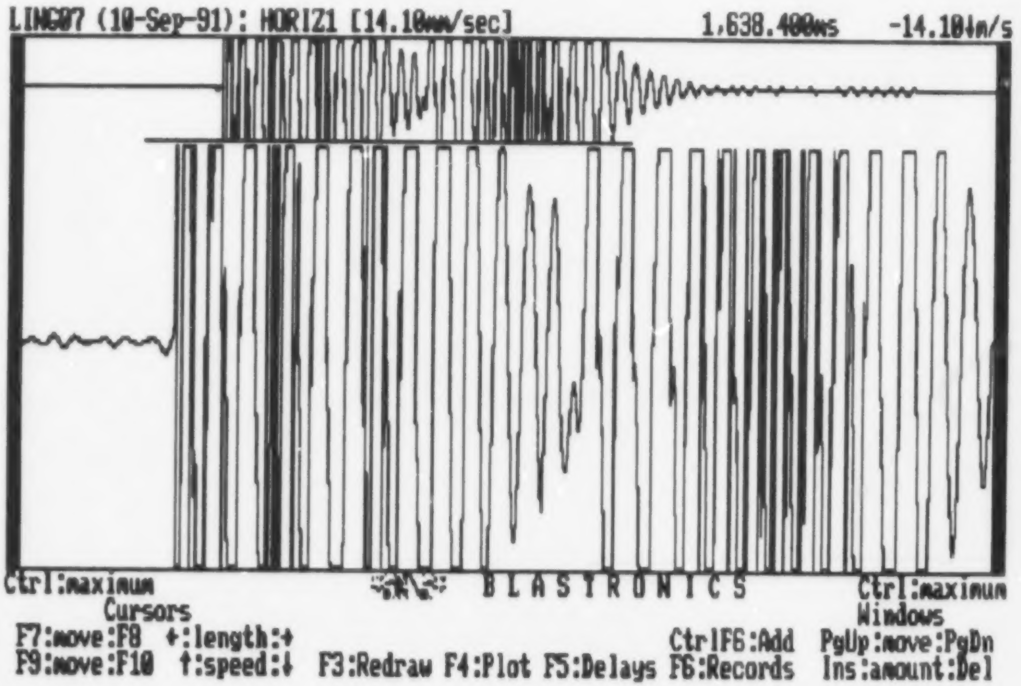


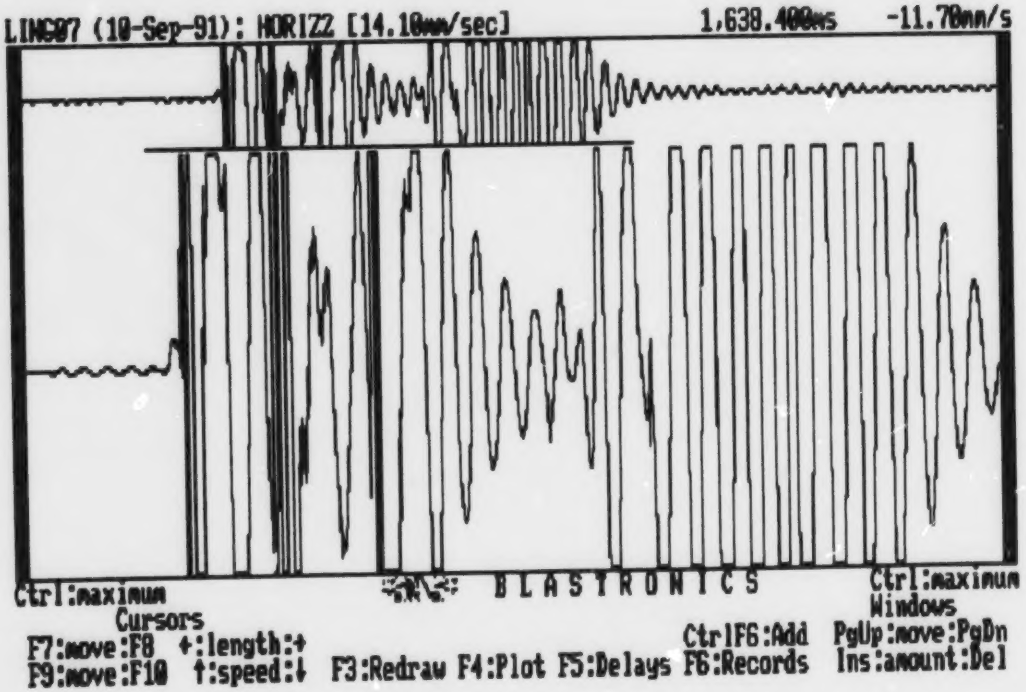
```
LIN096 (04-Sep-91): HORIZ1 [14.10mm/sec]          668.200ms     1.20mm/s
                              B L A S T R O N I C S
Ctrl:maximum                                                    Ctrl:maximum
   Cursors                                                         Windows
F7:move:F8  ←:length:→                          Ctrl F6:Add   PgUp:move:PgDn
F9:move:F10 ↑:speed:↓  F3:Redraw F4:Plot F5:Delays F6:Records  Ins:amount:Del
```


LING06 (04-Sep-91): HORIZZ [14.10mm/sec]
668.200ms
-0.10mm/s
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
B L A S T R O N I C S
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del



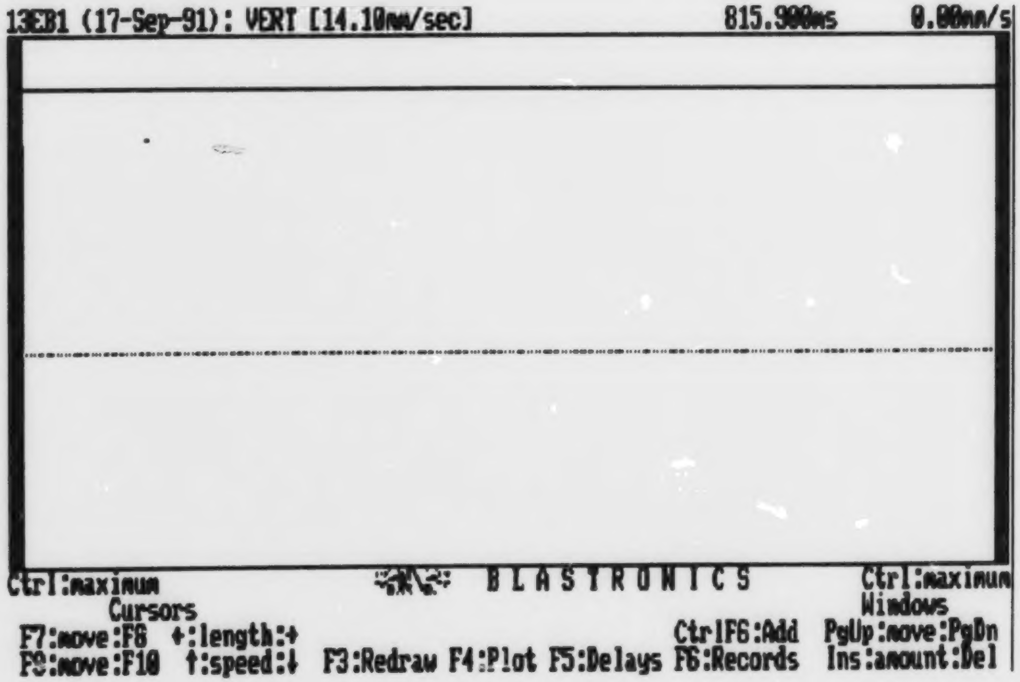
```
LIN007 (10-Sep-91): VERT [14.10mm/sec]↑          Detail window:   32,768.

Ctrl:maximum                                                     Ctrl:maximum
  Cursors          B L A S T R O N I C S                           Windows
F7:move:F8  ←:length:→   F3:Redraw F4:Plot F5:Delays CtrlF6:Add  PgUp:move:PgDn
F9:move:F10  ↑:speed:↓                               F6:Records Ins:amount:Del
```


LING07 (10-Sep-91): HORIZ1 [14.10mm/sec]
1,638.400ms
-14.10mm/s
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
BLASTRONICS
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del



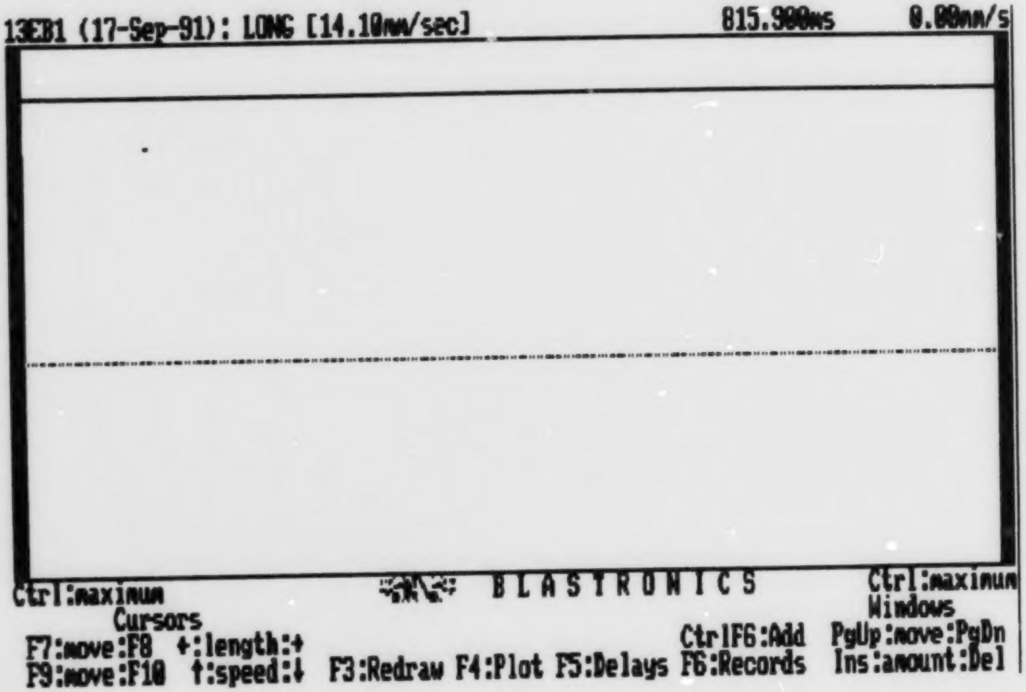
LING07 (10-Sep-91): HORIZ2 [14.10mm/sec] 1,638.400ms -11.70mm/s

BLASTRONICS
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

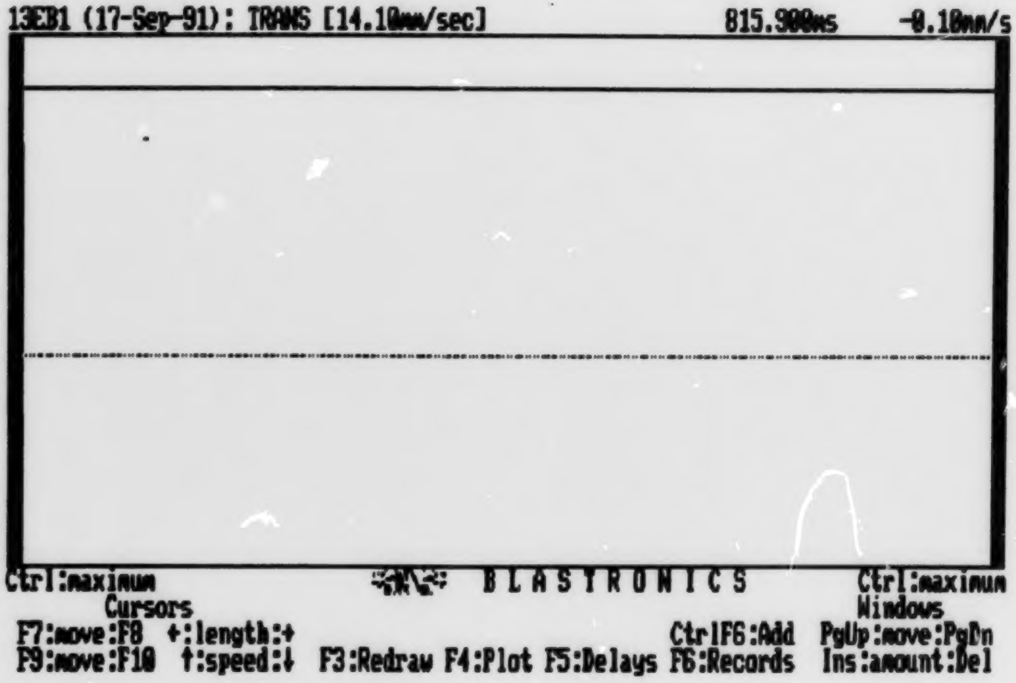


13EB1 (17-Sep-91): VERT [14.10mm/sec] 815.900ms 0.00mm/s

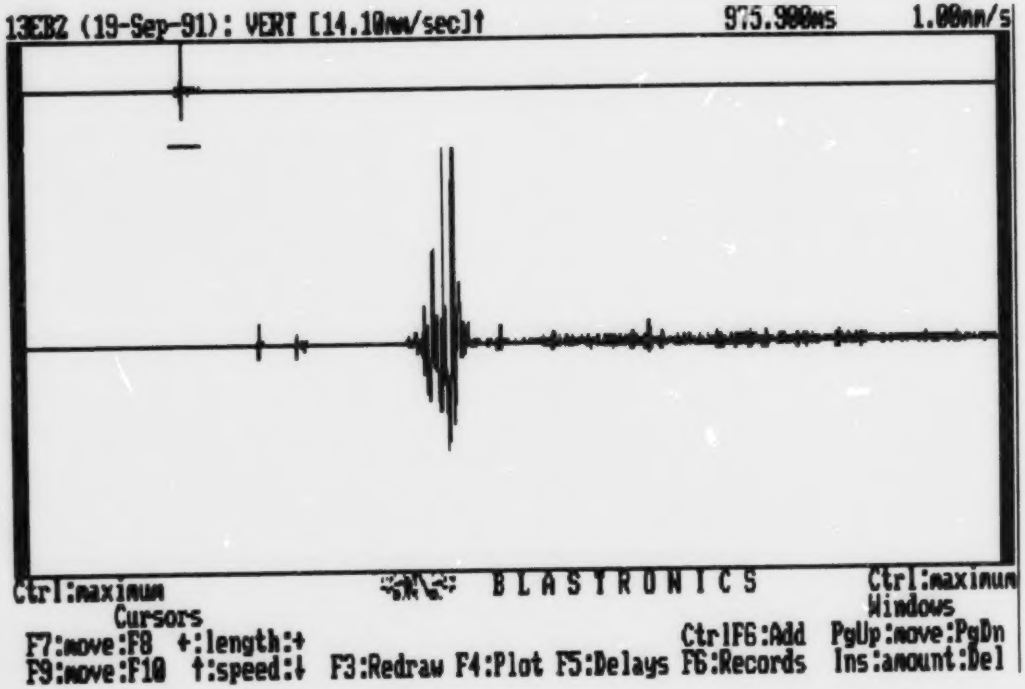
BLASTRONICS
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
Ctrl F6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del



```
13EB1 (17-Sep-91): LONG [14.10mm/sec]                815.900ms     0.00mm/s

Ctrl:maximum                       B L A S T R O N I C S          Ctrl:maximum
      Cursors                                                     Windows
 F7:move:F8  ←:length:→                              Ctrl F6:Add  PgUp:move:PgDn
 F9:move:F10  ↑:speed:↓  F3:Redraw F4:Plot F5:Delays F6:Records   Ins:amount:Del
```

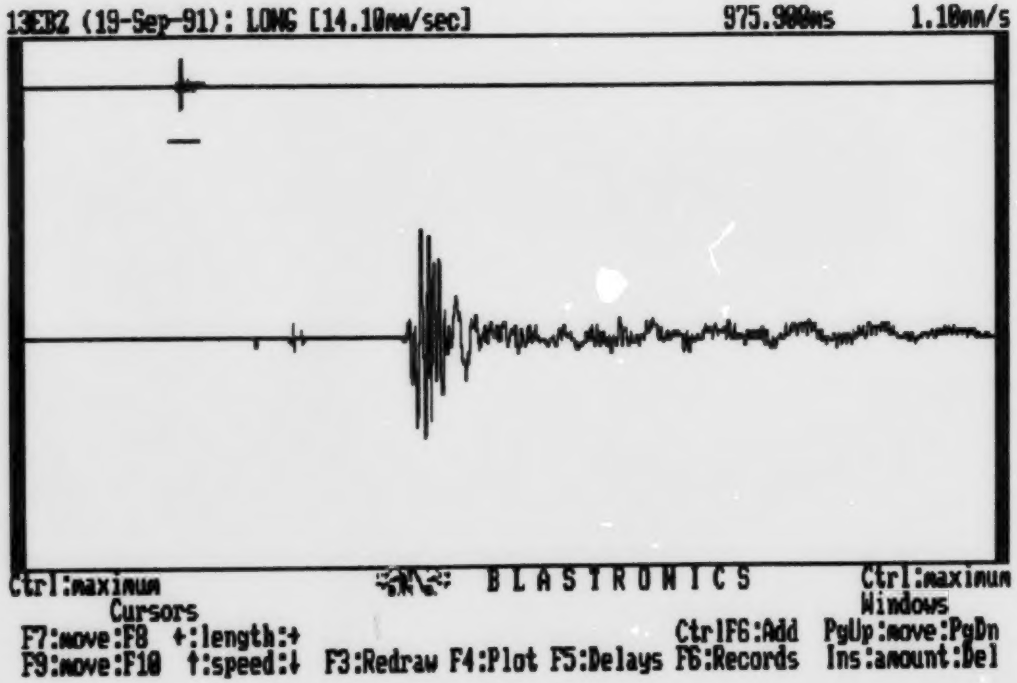


```
13EB1 (17-Sep-91): TRANS [14.10mm/sec]                815.900ms     -0.10mm/s

Ctrl:maximum                      B L A S T R O N I C S           Ctrl:maximum
     Cursors                                                       Windows
F7:move:F8  ←:length:→                               CtrlF6:Add  PgUp:move:PgDn
F9:move:F10  ↑:speed:↓  F3:Redraw F4:Plot F5:Delays F6:Records   Ins:amount:Del
```



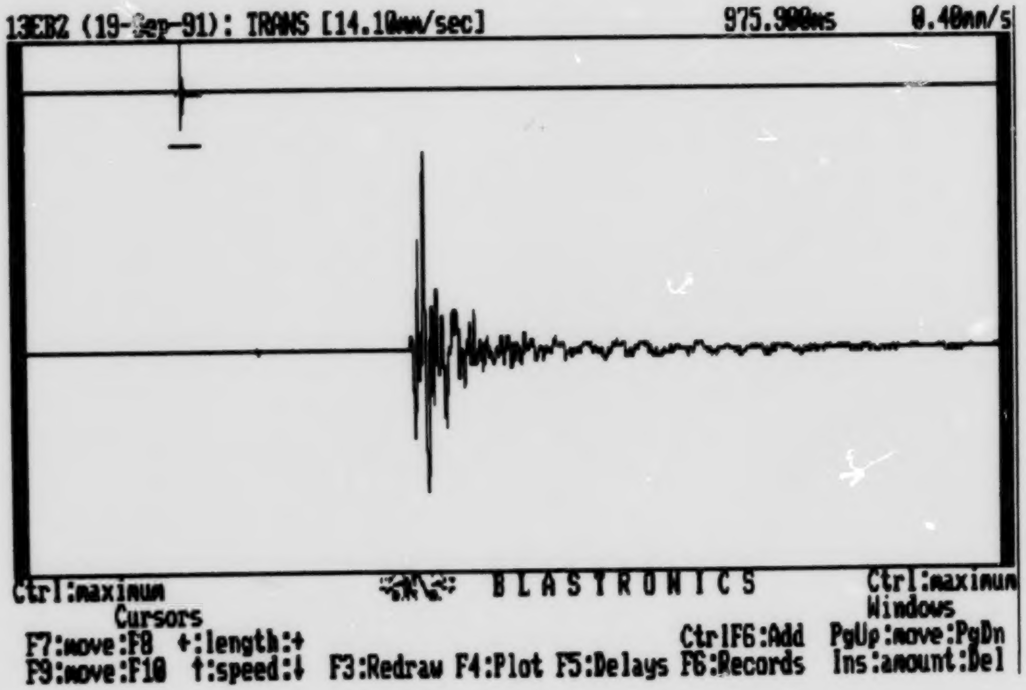
13EB2 (19-Sep-91): VERT [14.10mm/sec]↑ 975.900ms 1.00mm/s

BLASTRONICS
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

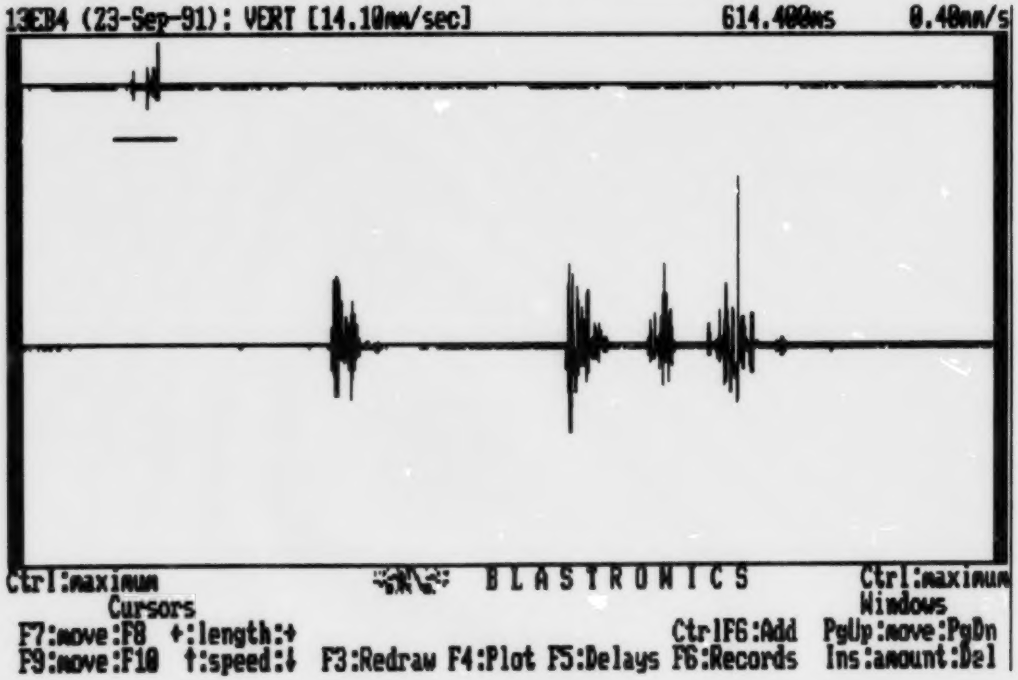


```
13EB2 (19-Sep-91): LONG [14.10mm/sec]                975.900ms      1.10mm/s
```

BLASTRONICS
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
Ctrl F6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

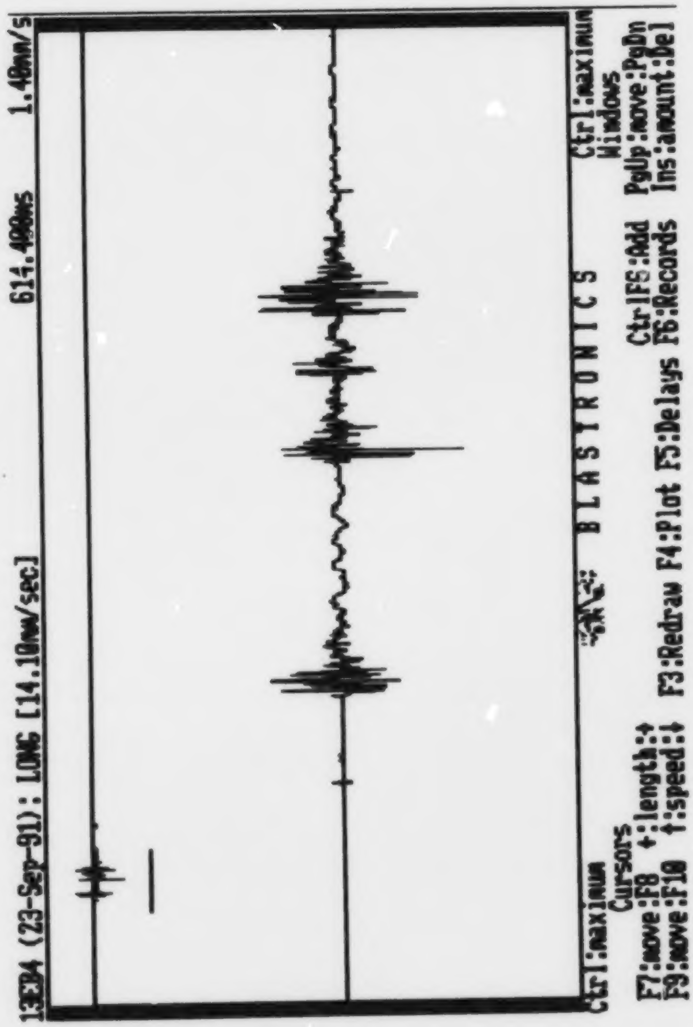


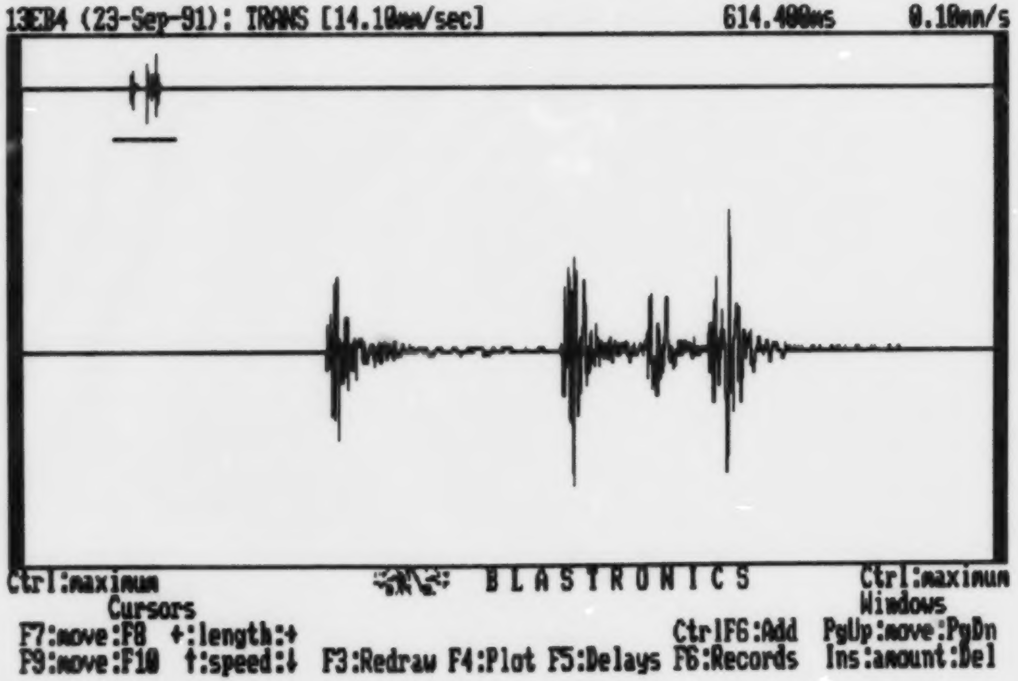
```
13EB2 (19-Sep-91): TRANS [14.10mm/sec]                975.900ms     0.40mm/s

Ctrl:maximum                  BLASTRONICS                        Ctrl:maximum
        Cursors                                                  Windows
 F7:move:F8  +:length:+                              CtrlF6:Add  PgUp:move:PgDn
 F9:move:F10  ↑:speed:↓  F3:Redraw F4:Plot F5:Delays F6:Records   Ins:amount:Del
```



13EB4 (23-Sep-91): VERT [14.10mm/sec] 614.400ms 0.40mm/s

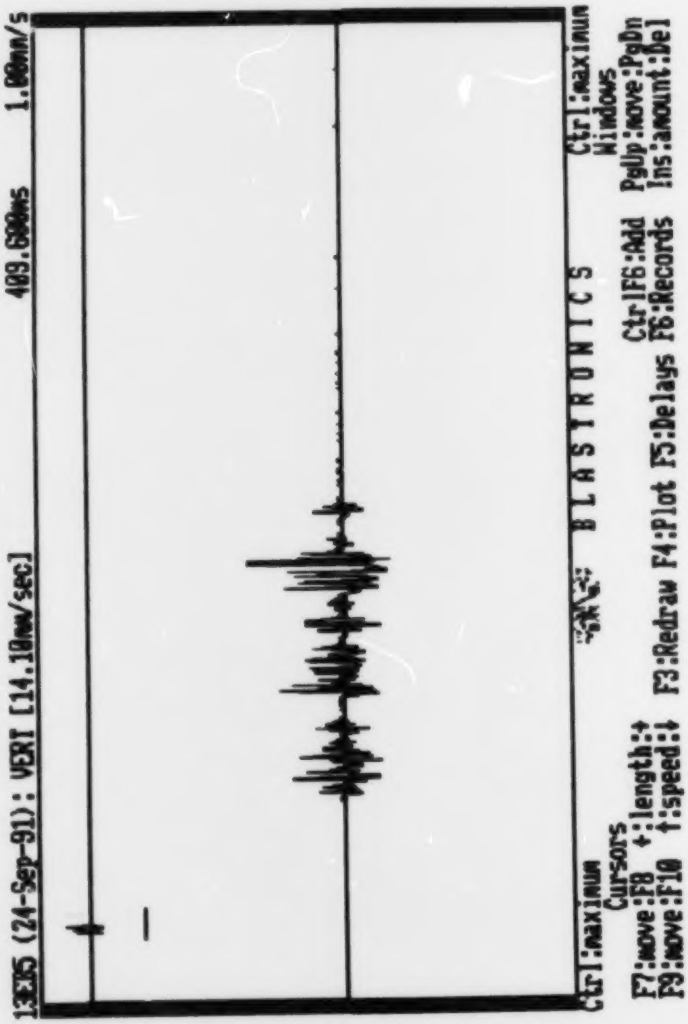
Ctrl:maximum
Cursors
F7:move:F8 +:length:+
F9:move:F10 ↑:speed:↓
BLASTRONICS
F3:Redraw F4:Plot F5:Delays
Ctrl F6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

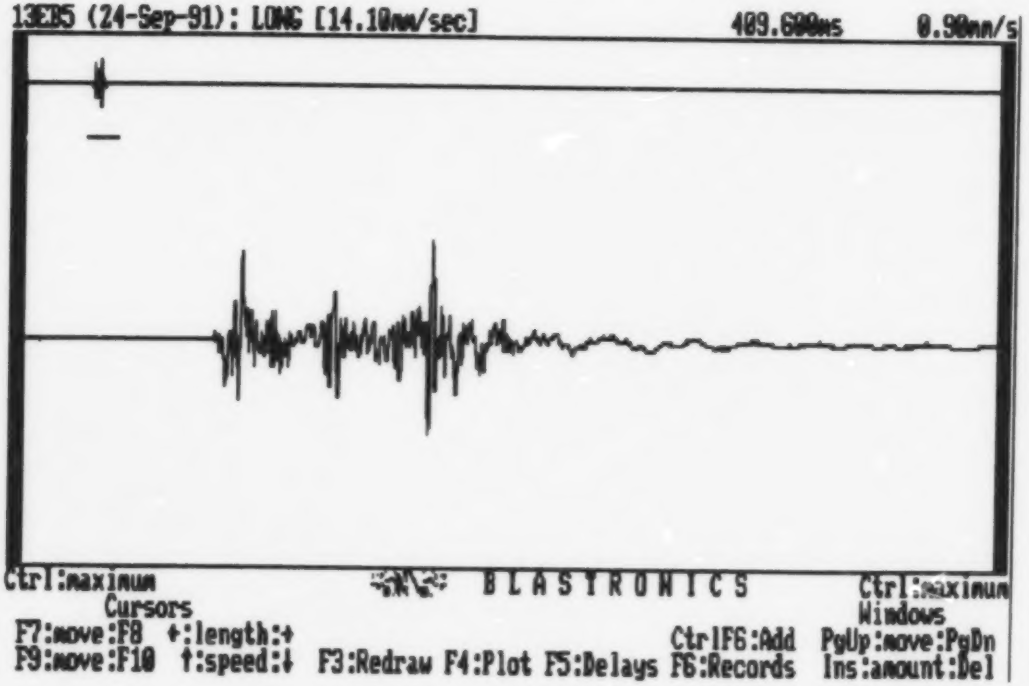

13E04 (23-Sep-91): LONG [14.10mm/sec]
614.400ms
1.40mm/s
BLASTRONICS
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays F6:Records
Ctrl F5:Add
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

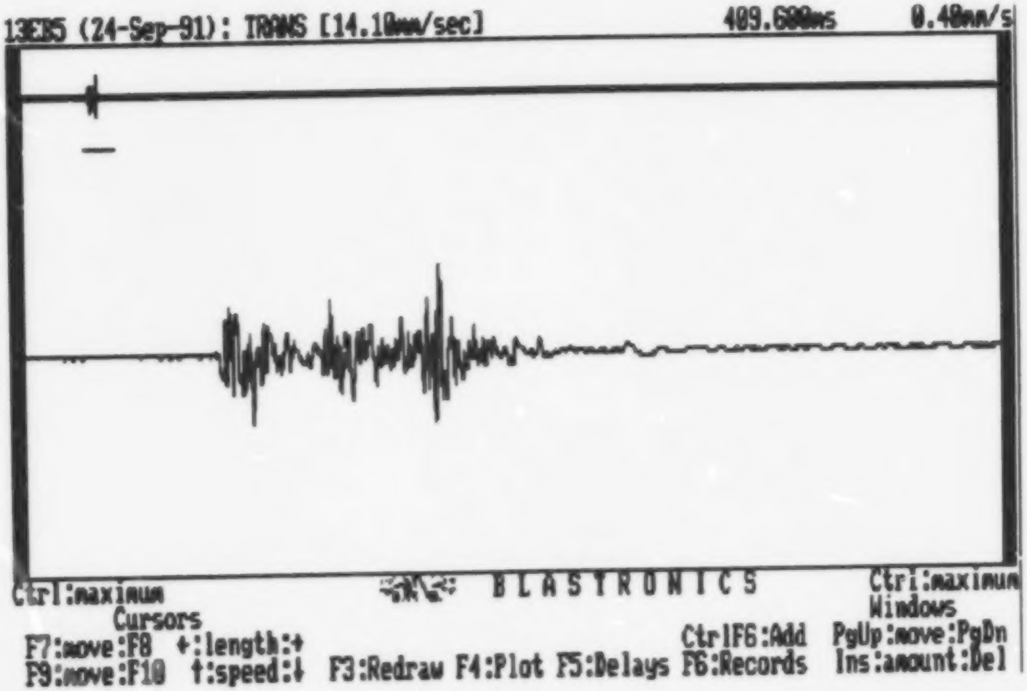


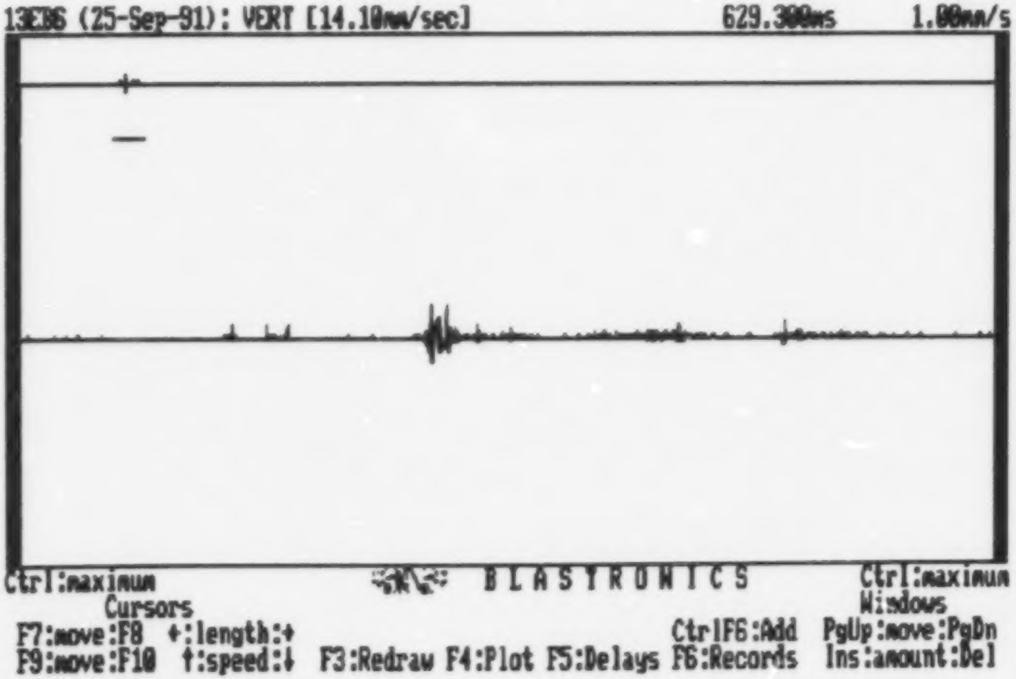
```
13EB4 (23-Sep-91): TRANS [14.10mm/sec]          614.400ms     0.10mm/s
```

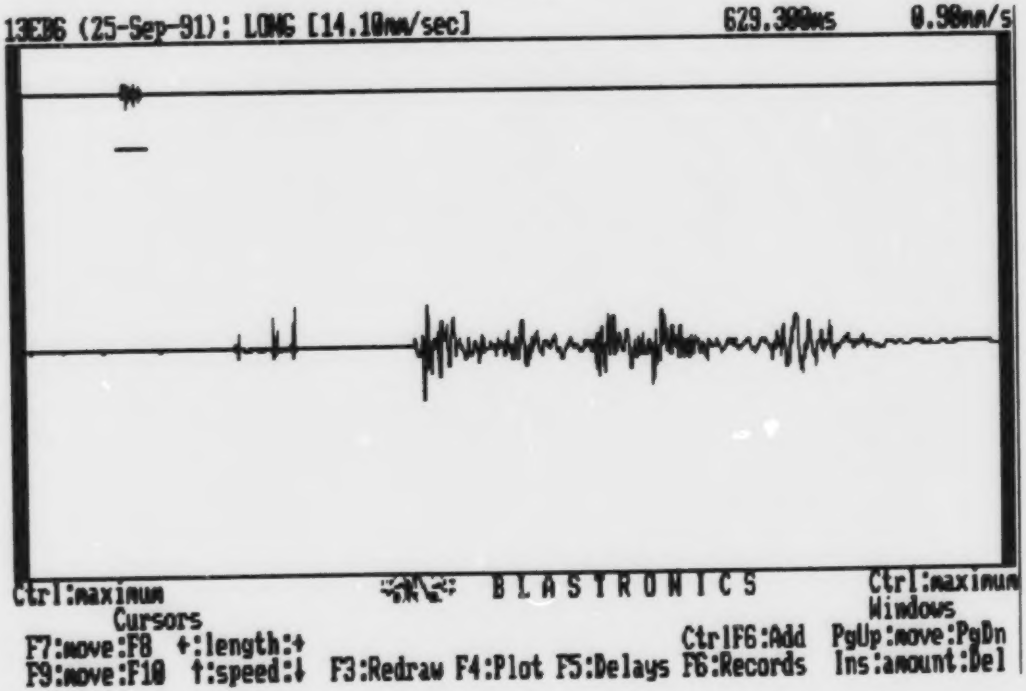
BLASTRONICS
Ctrl:maximum
Cursors
F7:move:F8 +:length:+
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

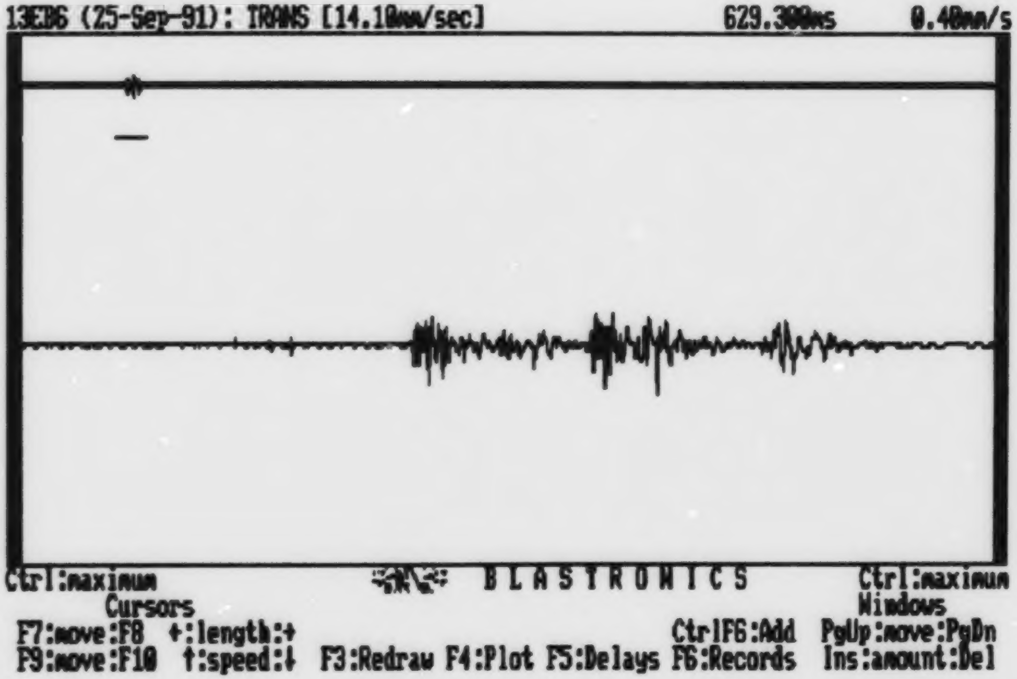

13E05 (24-Sep-91): VERT [14.10mm/sec]
409.600ms
1.00mm/s
B L A S T R O N I C S
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays F6:Records
CtrlF6:Add
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del


13EB5 (24-Sep-91): LONG [14.10mm/sec]
409.600ms
0.90mm/s
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
BLASTRONICS
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del


13E05 (24-Sep-91): TRANS [14.10mm/sec]
409.600ms
0.40mm/s
BLASTRONICS
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

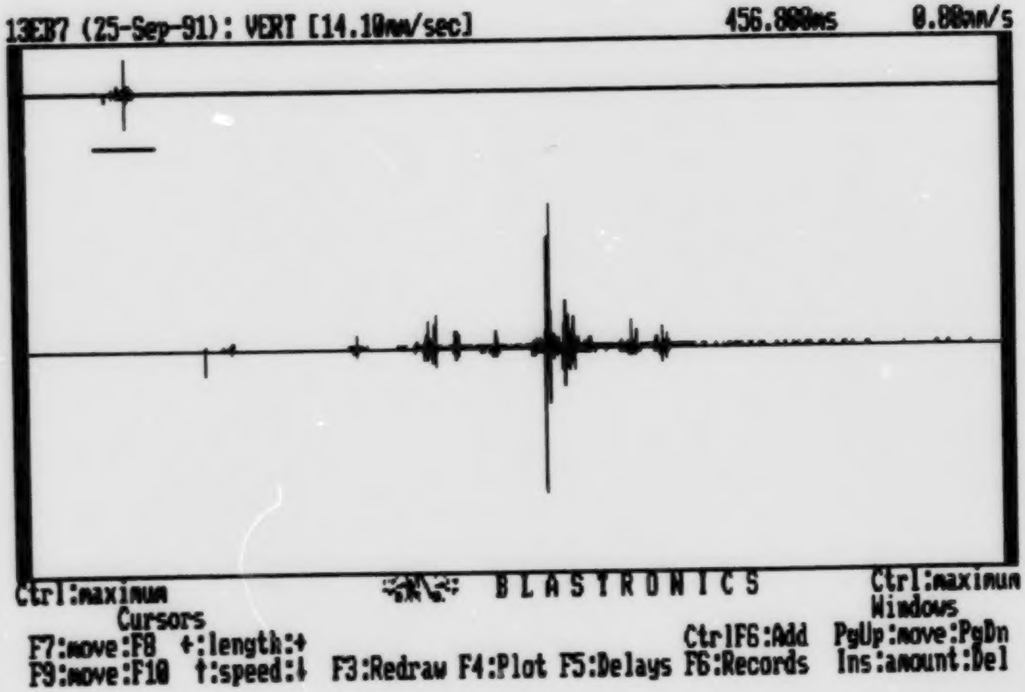

13EB6 (25-Sep-91): VERT [14.10mm/sec]
629.300ms
1.00mm/s
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
BLASTRONICS
Ctrl F6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del


13EB6 (25-Sep-91): LONG [14.10mm/sec]
629.300ms
0.98mm/s
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
B L A S T R O N I C S
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

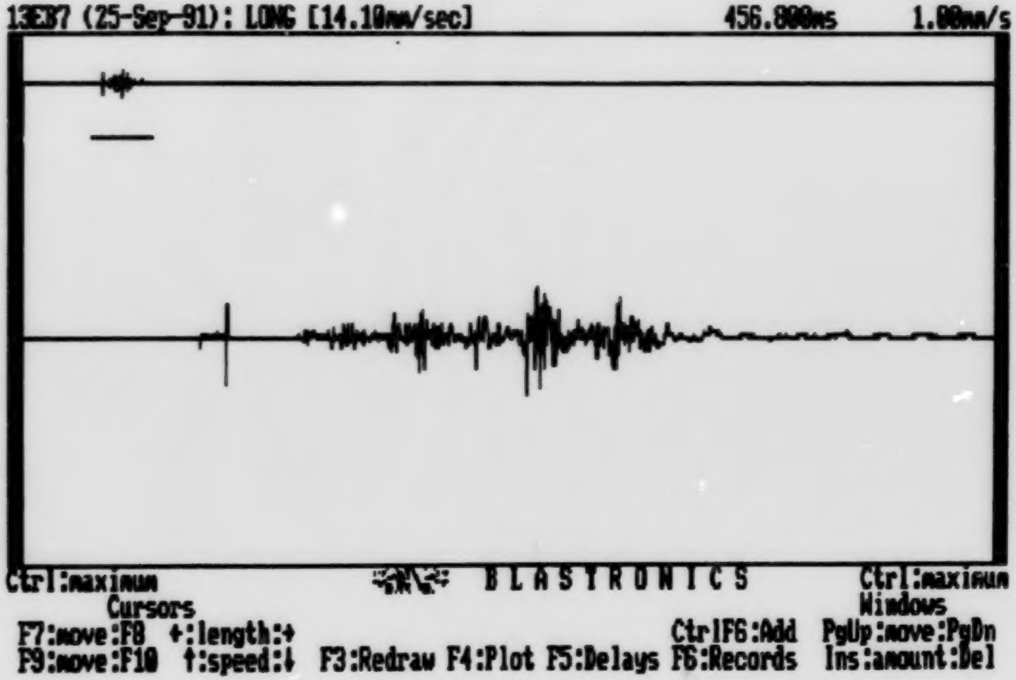


13EB6 (25-Sep-91): TRANS [14.10mm/sec]   629.300ms   0.40mm/s

Ctrl:maximum
Cursors
F7:move:F8 +:length:+
F9:move:F10 ↑:speed:↓
BLASTRONICS
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

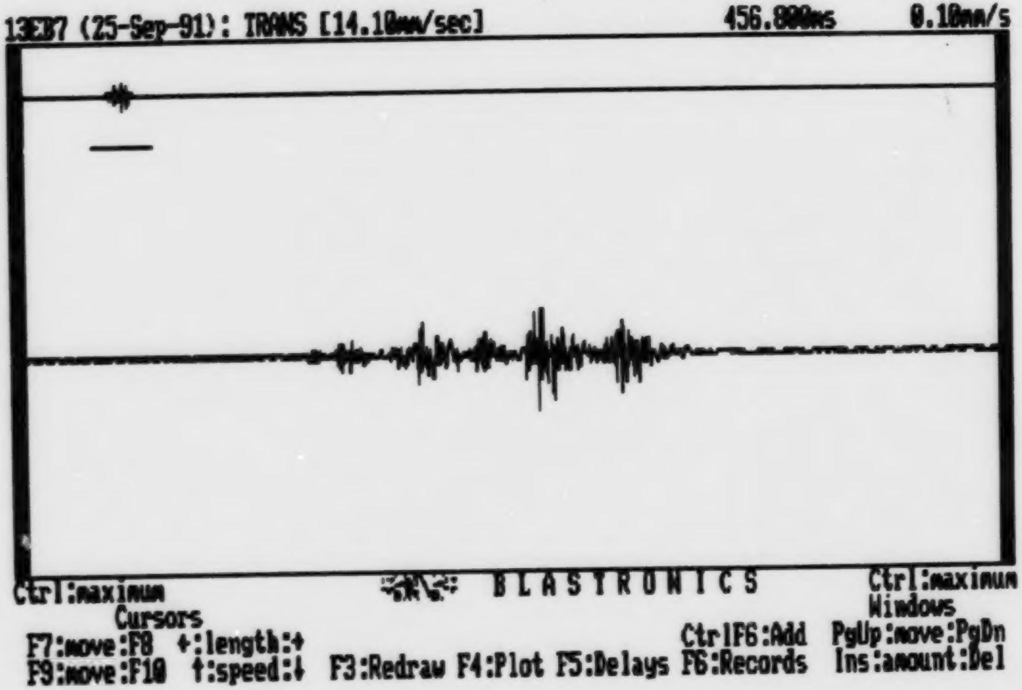


```
13EB7 (25-Sep-91): VERT [14.10mm/sec]                    456.000ms     0.00mm/s

Ctrl:maximum                          BLASTRONICS                  Ctrl:maximum
     Cursors                                                       Windows
 F7:move:F8  ←:length:→                             CtrlF6:Add   PgUp:move:PgDn
 F9:move:F10  ↑:speed:↓  F3:Redraw F4:Plot F5:Delays F6:Records    Ins:amount:Del
```



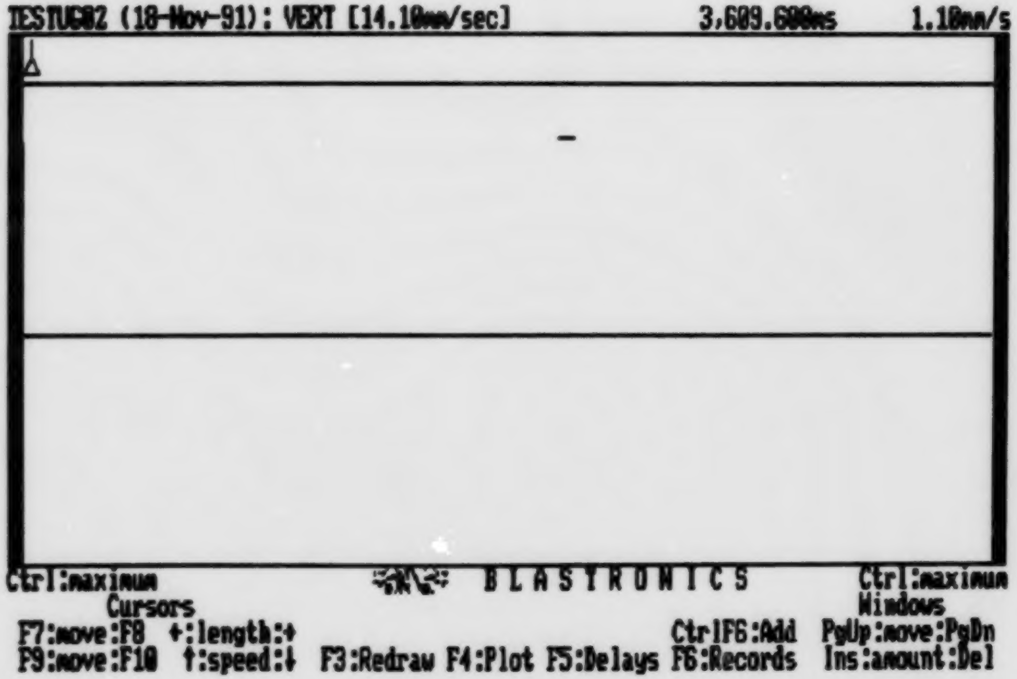
13EB7 (25-Sep-91): LONG [14.10mm/sec]

456.800ms
1.00mm/s
BLASTRONICS
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays F6:Records
CtrlF6:Add
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del



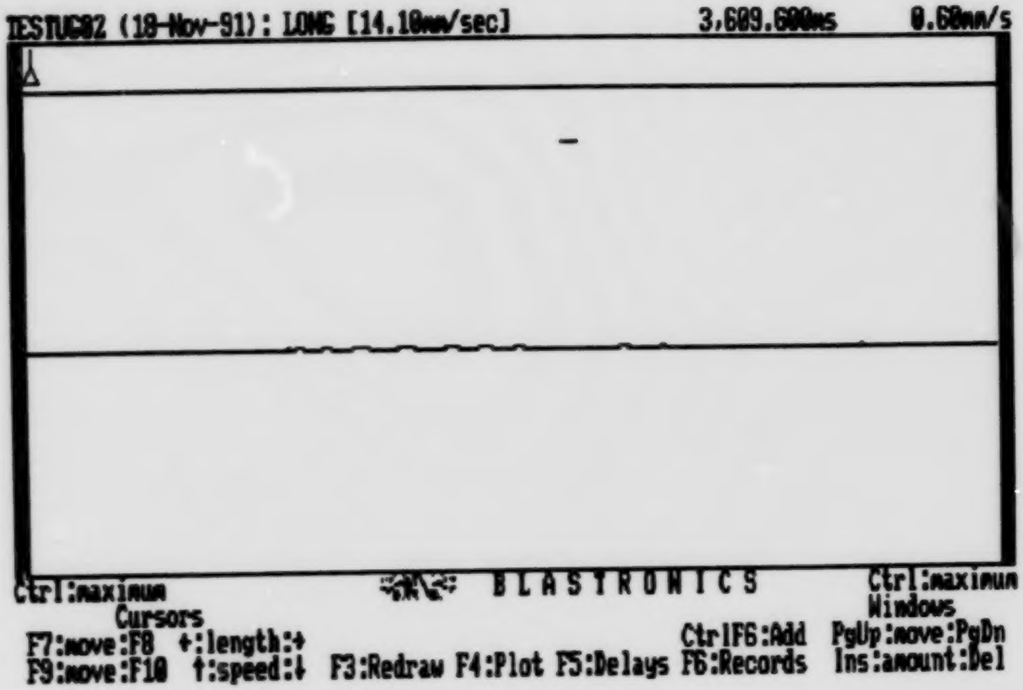
13EB7 (25-Sep-91): TRANS [14.10mm/sec] 456.800ms 0.10mm/s

BLASTRONICS
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del



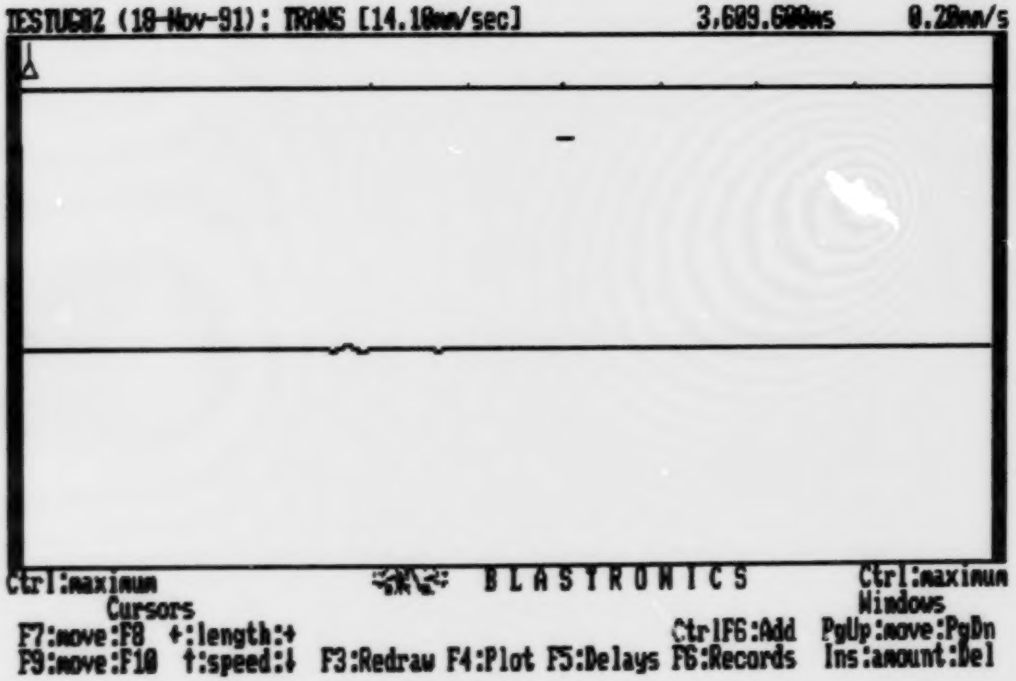
```
TESTUG02 (18-Nov-91): VERT [14.10mm/sec]          3,609.600ms     1.10mm/s
```

Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
BLASTRONICS
F3:Redraw F4:Plot F5:Delays
Ctrl F6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del



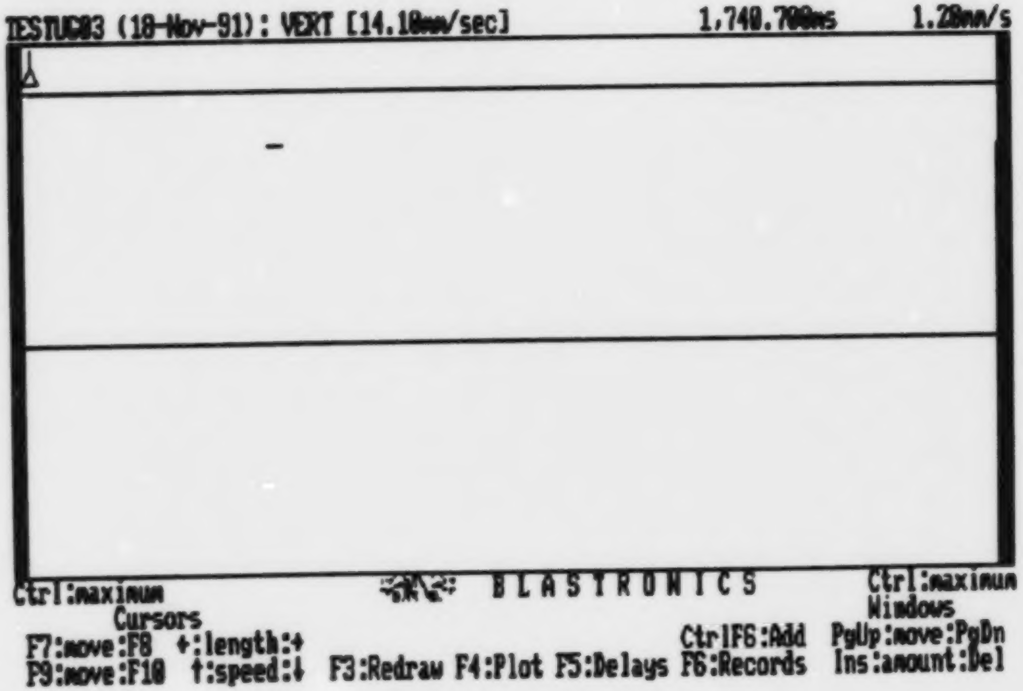
```
TESTUG02 (18-Nov-91): LONG [14.10mm/sec]          3,609.600ms     0.60mm/s
```

BLASTRONICS
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
Ctrl F6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del



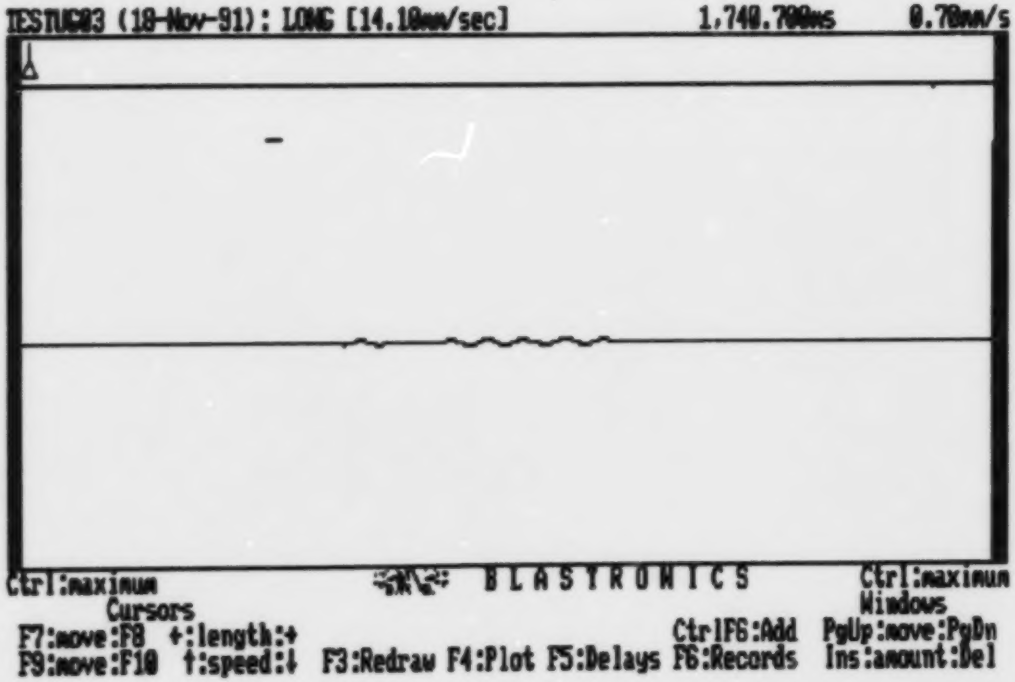
```
TESTUG02 (18-Nov-91): TRANS [14.10mm/sec]          3,609.600ms     0.20mm/s
```

Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
B L A S T R O N I C S
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del



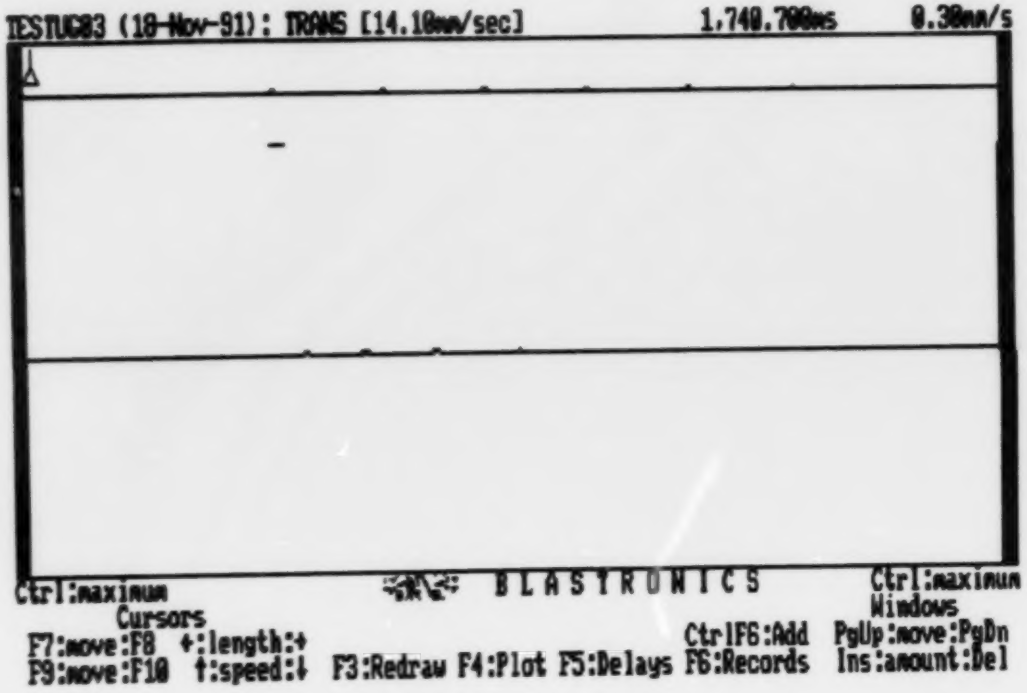
```
TESTUG03 (18-Nov-91): VERT [14.10mm/sec]          1,740.700ms     1.28mm/s
```

B L A S T R O N I C S
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
Ctrl F6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

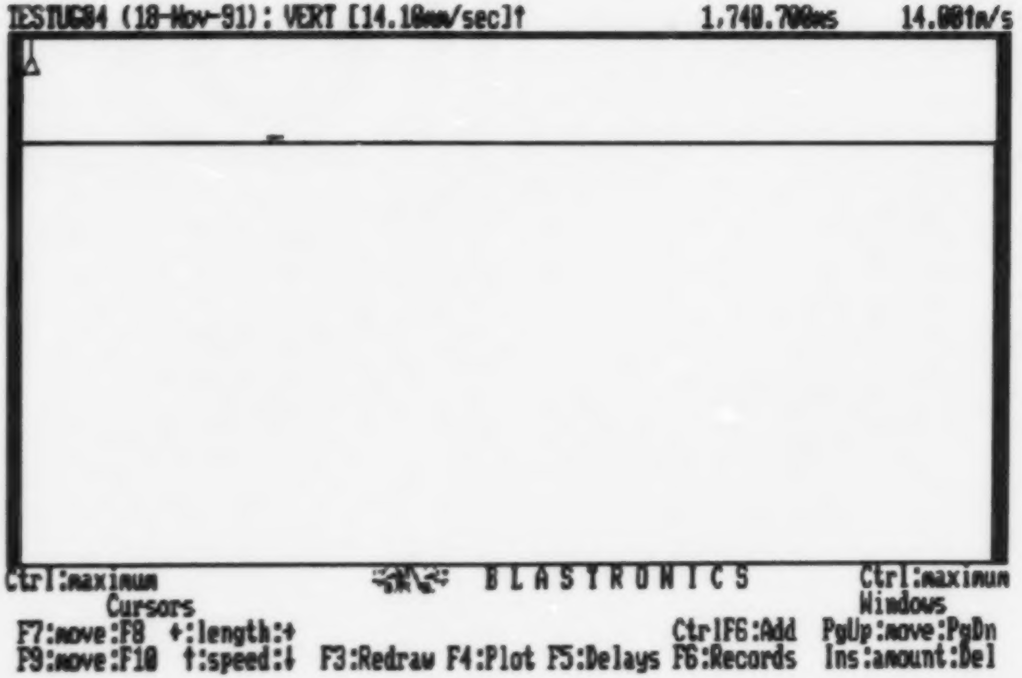


TESTUG03 (18-Nov-91): LONG [14.10mm/sec] 1,740.700ms 0.70mm/s

BLASTRONICS
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

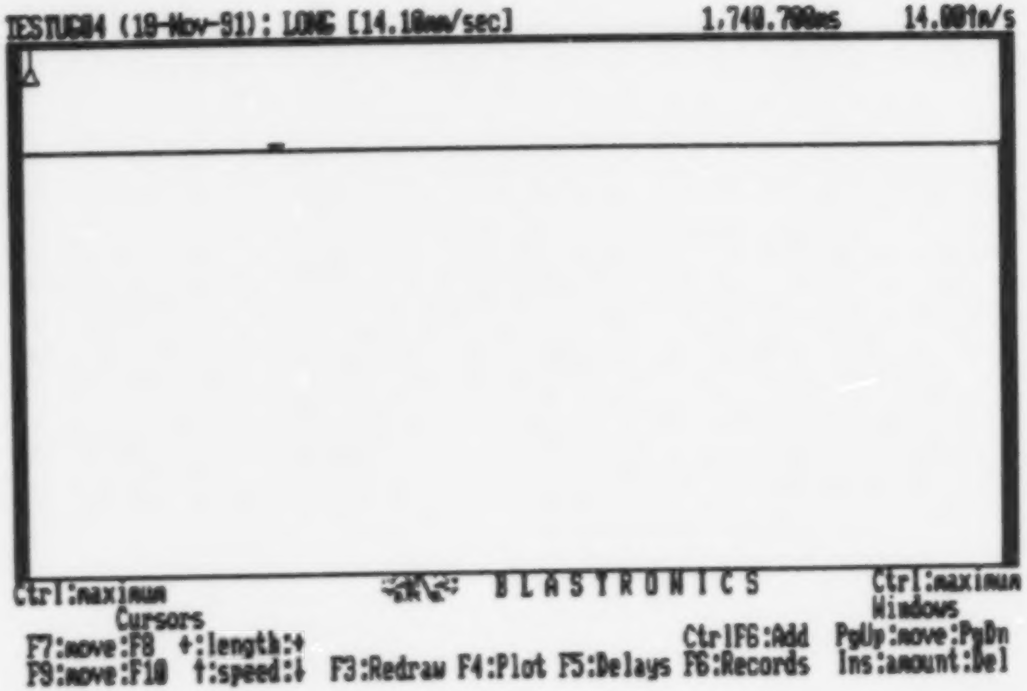


```
TESTUG03 (18-Nov-91): TRANS [14.10mm/sec]          1,740.700ms     0.30mm/s

Ctrl:maximum                       BLASTRONICS                       Ctrl:maximum
       Cursors                                                        Windows
 F7:move:F8  ←:length:→                               Ctrl F6:Add  PgUp:move:PgDn
 F9:move:F10  ↑:speed:↓  F3:Redraw F4:Plot F5:Delays F6:Records   Ins:amount:Del
```



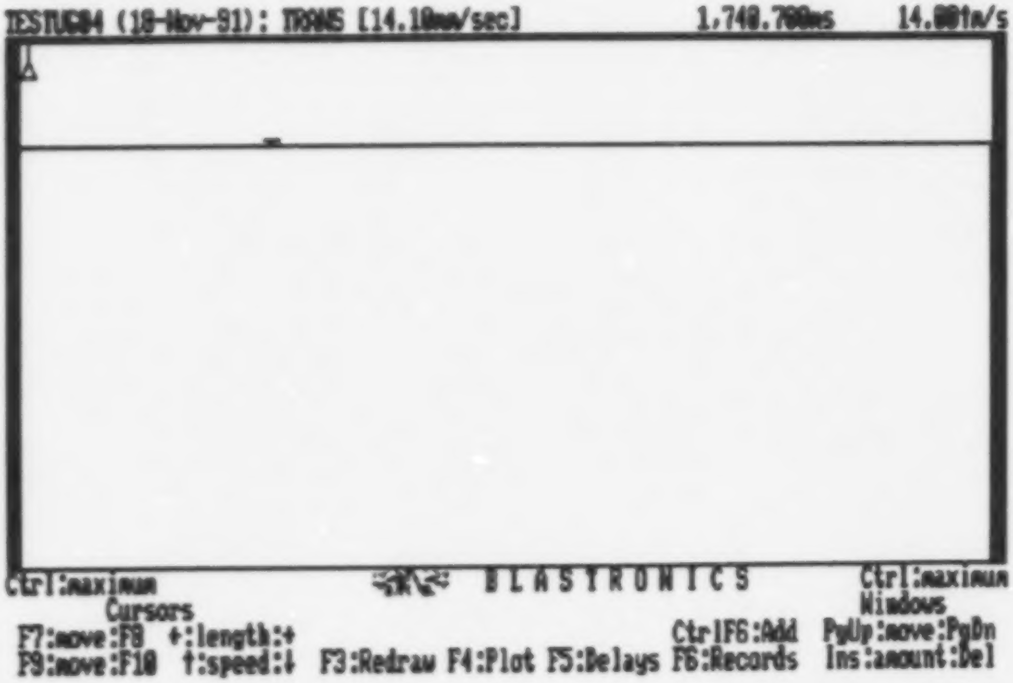
```
TESTUG84 (18-Nov-91): VERT [14.10mm/sec]↑          1,740.700ms    14.00in/s
```

Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
BLASTRONICS
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

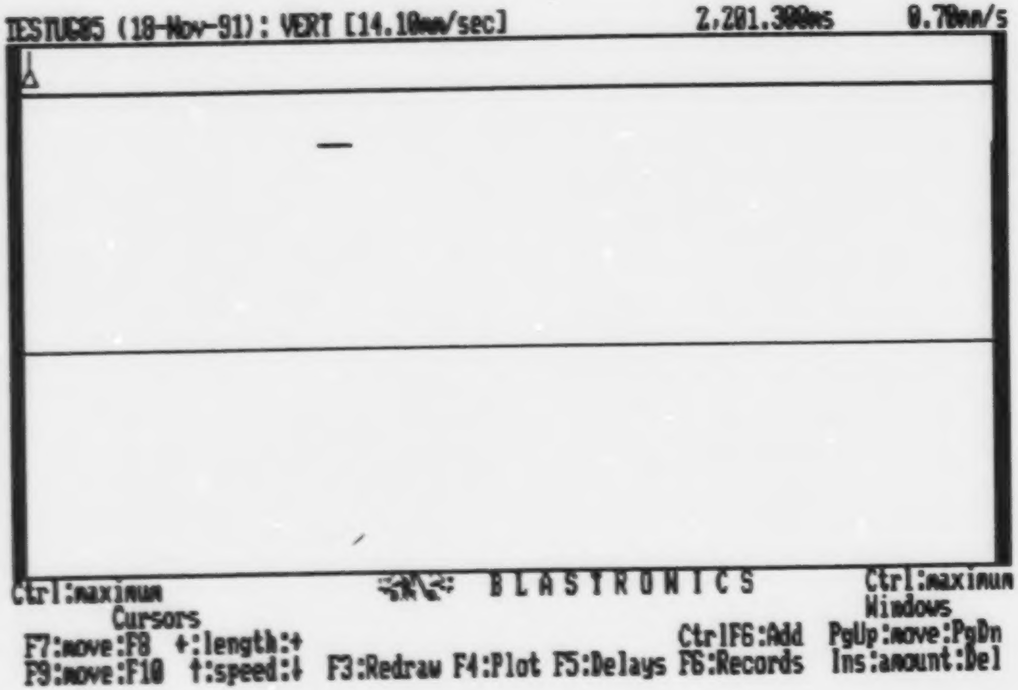


```
TESTUG04 (19-Nov-91): LONG [14.10mm/sec]          1,740.700ms    14.001m/s
```

BLASTRONICS
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

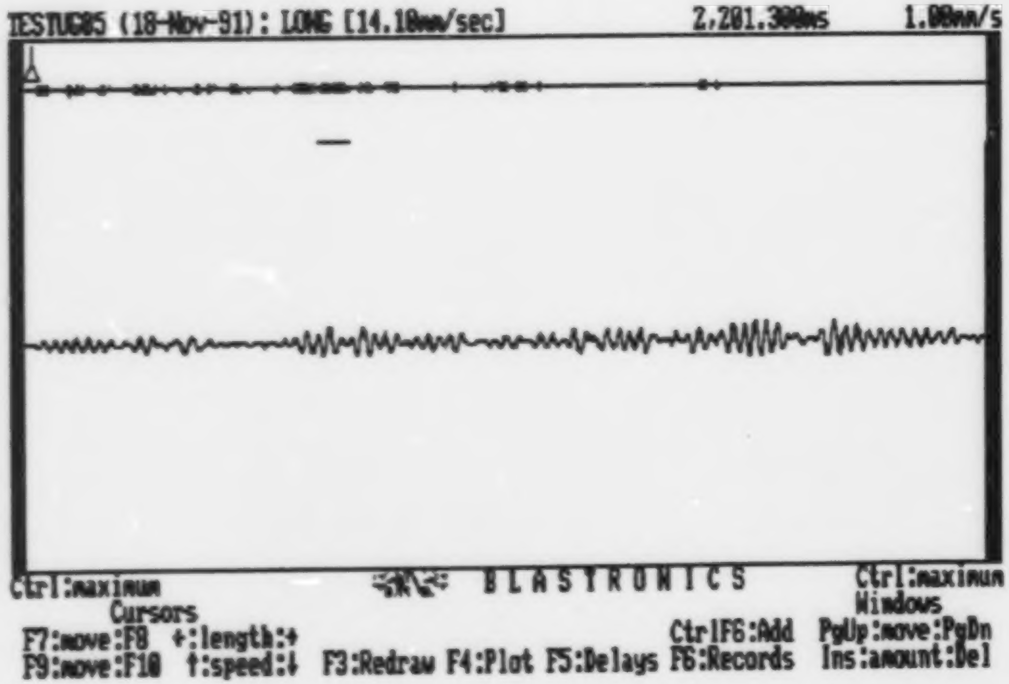


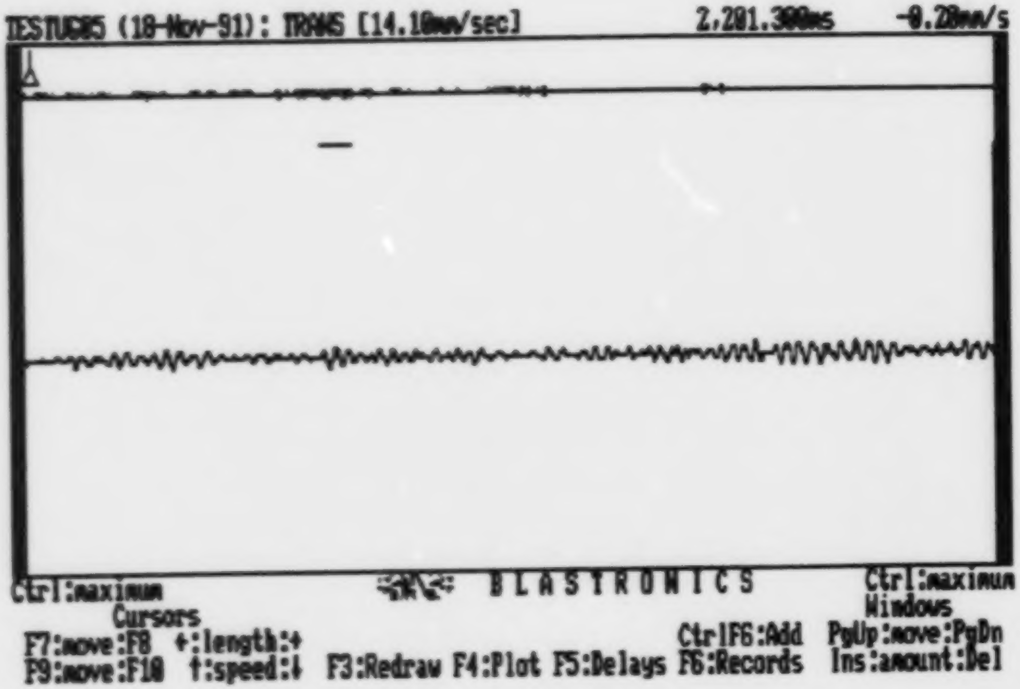
```
TESTUG04 (18-Nov-91): TRANS [14.10mm/sec]          1,740.700ms    14.00in/s

Ctrl:maximum                     BLASTRONICS                Ctrl:maximum
         Cursors                                            Windows
F7:move:F8  ←:length:→                          CtrlF6:Add  PgUp:move:PgDn
F9:move:F10  ↑:speed:↓  F3:Redraw F4:Plot F5:Delays F6:Records  Ins:amount:Del
```



TESTUG05 (18-Nov-91): VERT [14.10mm/sec] 2,201.300ms 0.70mm/s

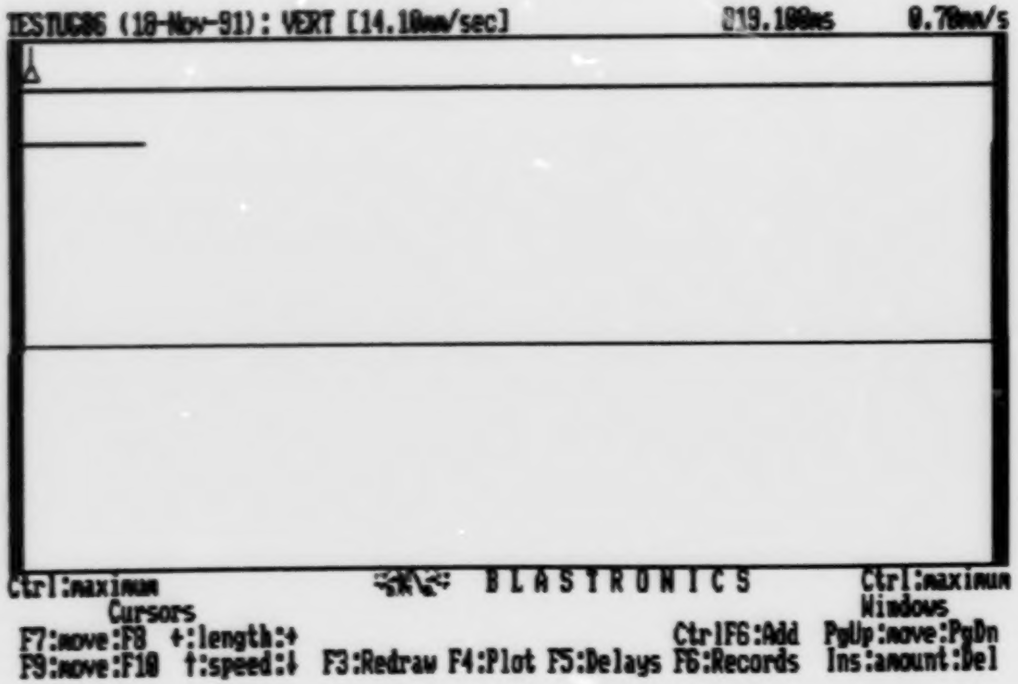
BLASTRONICS
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

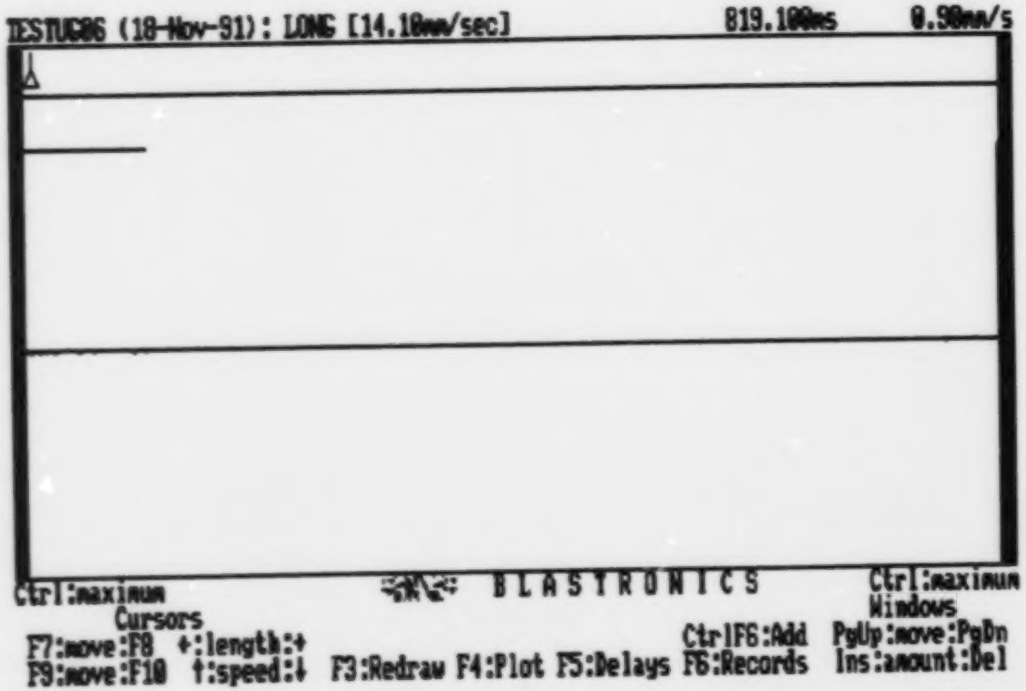

TESTUG05 (18-Nov-91): LONG [14.10mm/sec]
2,201.300ms
1.00mm/s
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
BLASTRONICS
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del



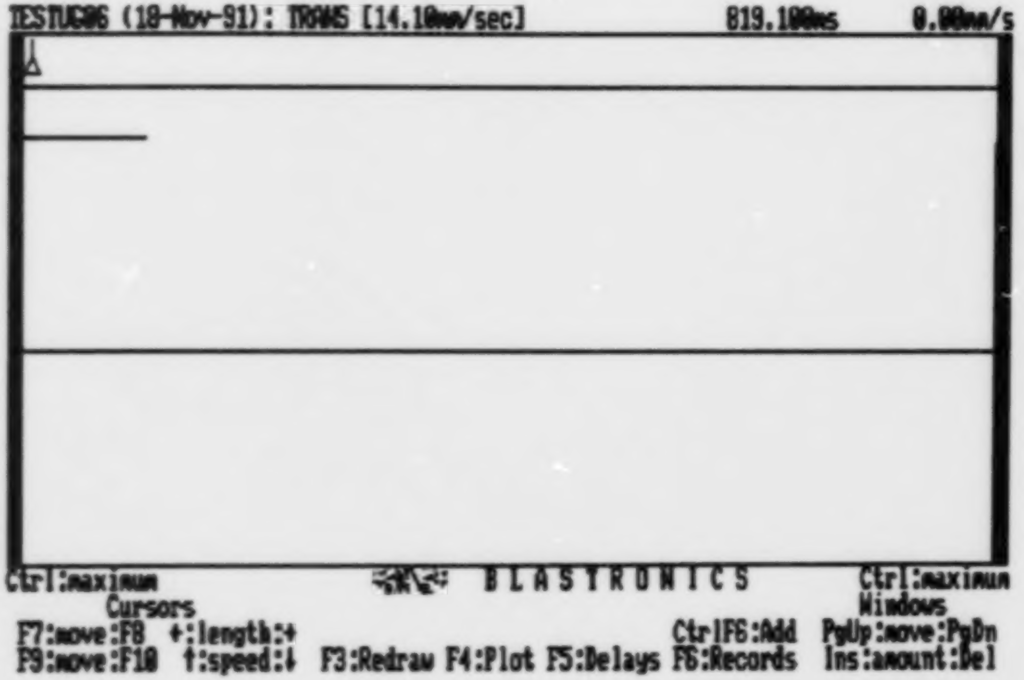
TESTUG05 (18-Nov-91): TRANS [14.10mm/sec] 2,201.300ms -0.20mm/s

Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
BLASTRONICS
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

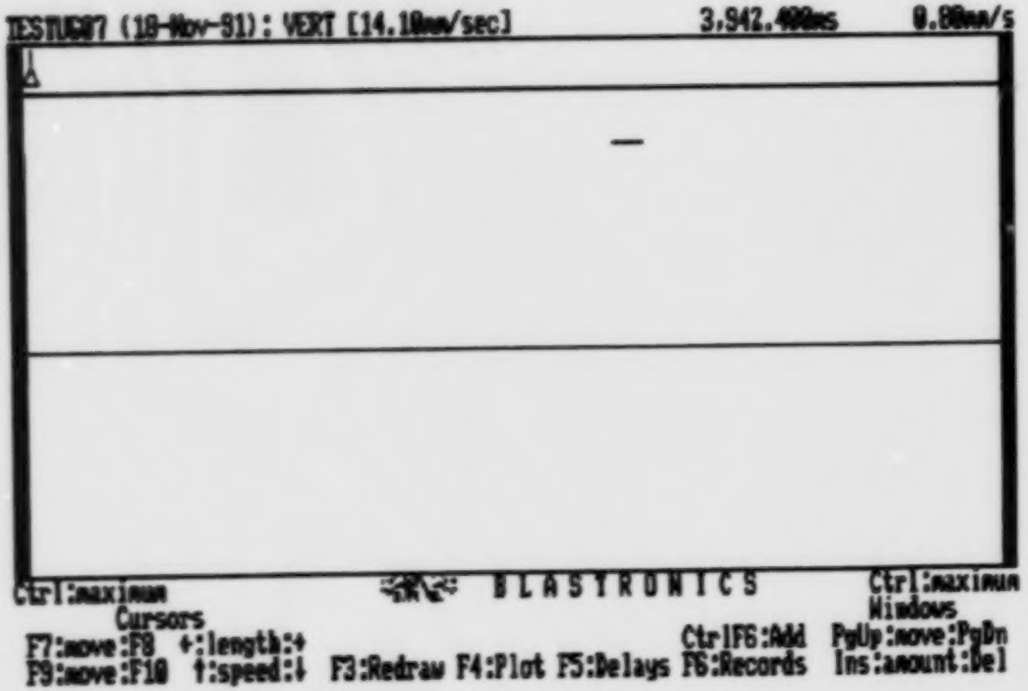

TESTUG06 (18-Nov-91): VERT [14.10mm/sec]
019.100ms
0.70mm/s
Ctrl:maximum
Cursors
F7:move:F8
←:length:→
F9:move:F10
↑:speed:↓
F3:Redraw
F4:Plot
F5:Delays
BLASTRONICS
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del



```
TESTUG06 (18-Nov-91): LONG [14.10mm/sec]          819.100ms     0.90mm/s

Ctrl:maximum                 B L A S T R O N I C S              Ctrl:maximum
        Cursors                                                 Windows
                                                   CtrlF6:Add  PgUp:move:PgDn
F7:move:F8  ←:length:→
F9:move:F10  ↑:speed:↓  F3:Redraw F4:Plot F5:Delays F6:Records  Ins:amount:Del
```

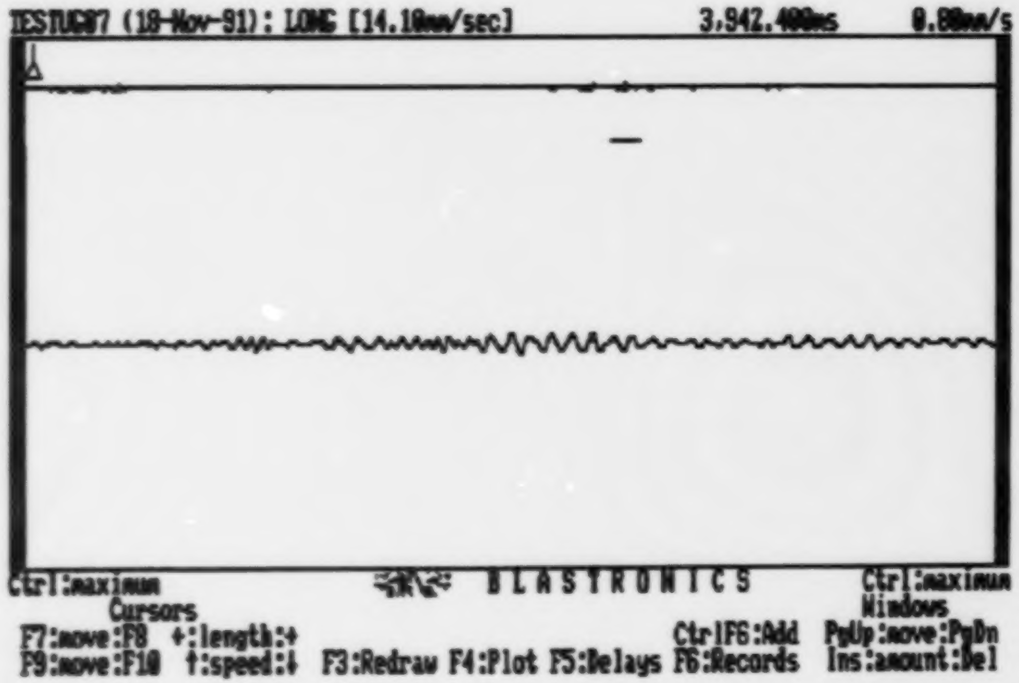


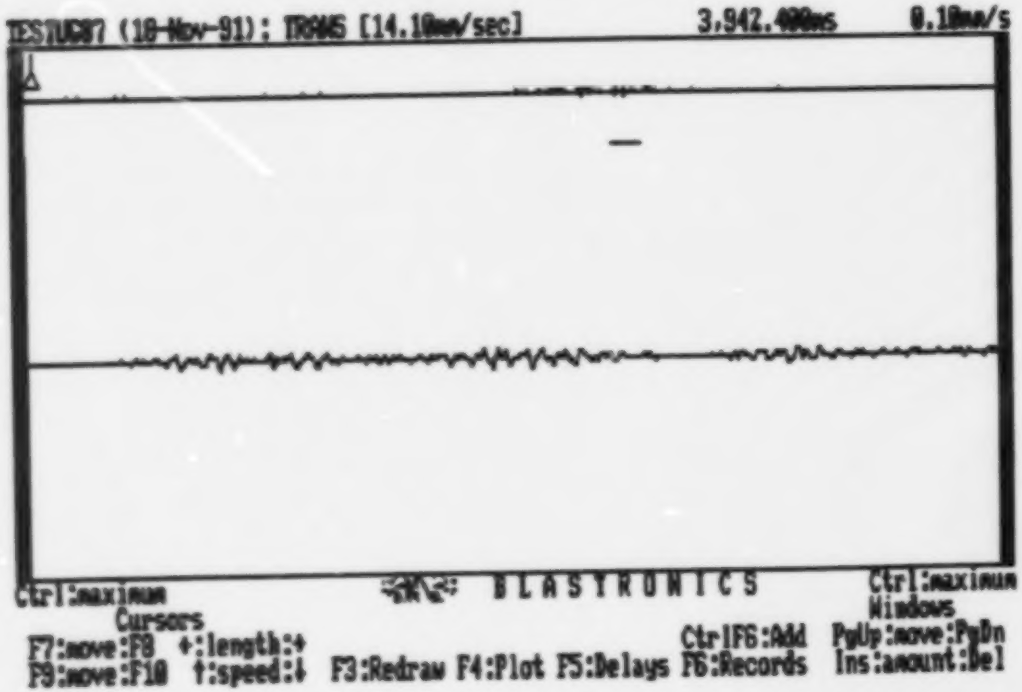
```
TESTUG06 (18-Nov-91): TRANS [14.10mm/sec]              819.100ms     0.00mm/s

Ctrl:maximum                      B L A S T R O N I C S           Ctrl:maximum
       Cursors                                                     Windows
 F7:move:F8  ←:length:→                              CtrlF6:Add  PgUp:move:PgDn
 F9:move:F10  ↑:speed:↓  F3:Redraw F4:Plot F5:Delays F6:Records  Ins:amount:Del
```

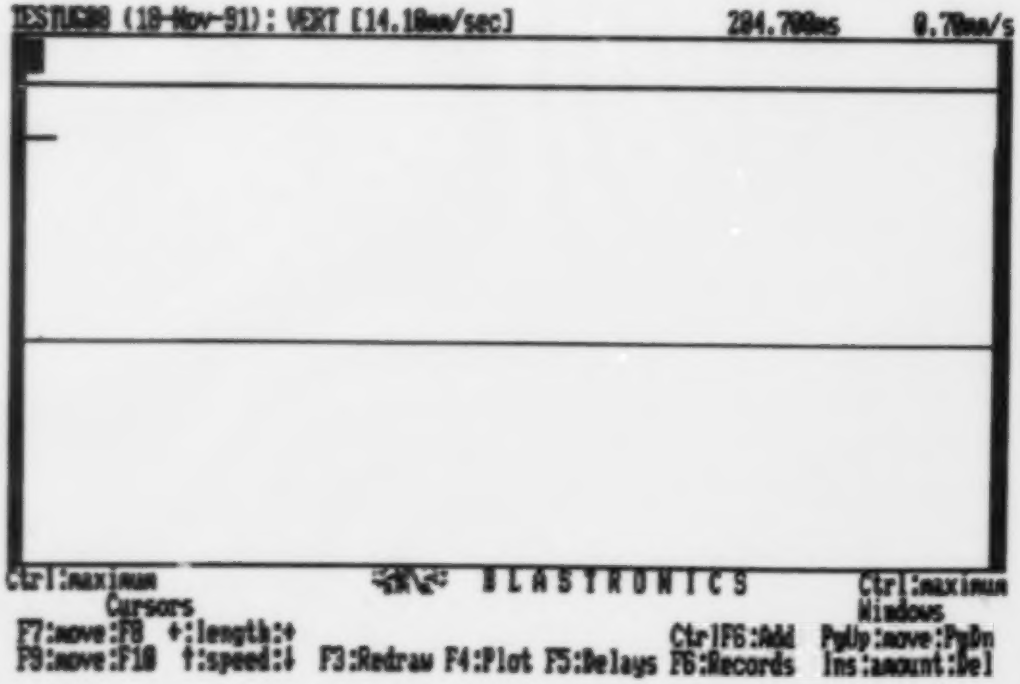


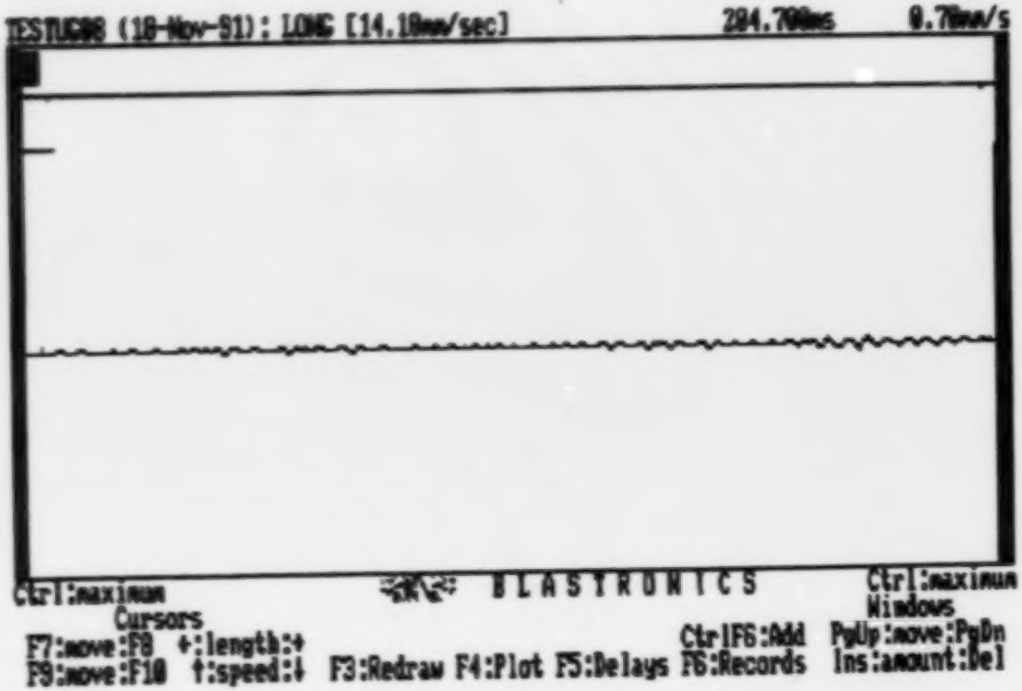
```
TESTUG07 (18-Nov-91): VERT [14.10mm/sec]            3,942.400ms     0.00mm/s
```

```
Ctrl:maximum                    B L A S T R O N I C S                 Ctrl:maximum
      Cursors                                                          Windows
 F7:move:F8  ←:length:→                             CtrlF6:Add  PgUp:move:PgDn
 F9:move:F10  ↑:speed:↓  F3:Redraw F4:Plot F5:Delays F6:Records  Ins:amount:Del
```


TESTUG07 (18-Nov-91): LONG [14.10mm/sec]
3,942.400ms
0.80mm/s
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
BLASTRONICS
Ctrl F6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

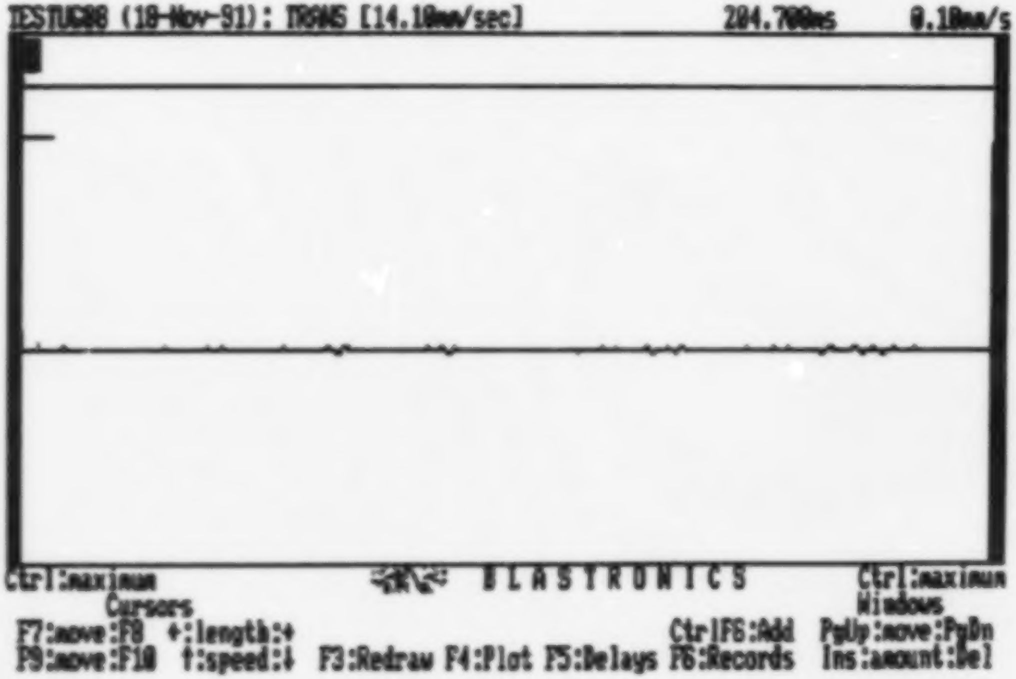

TESTUG07 (18-Nov-91): TRANS [14.10mm/sec]
3,942.400ms
0.10mm/s
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
BLASTRONICS
Ctrl F6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

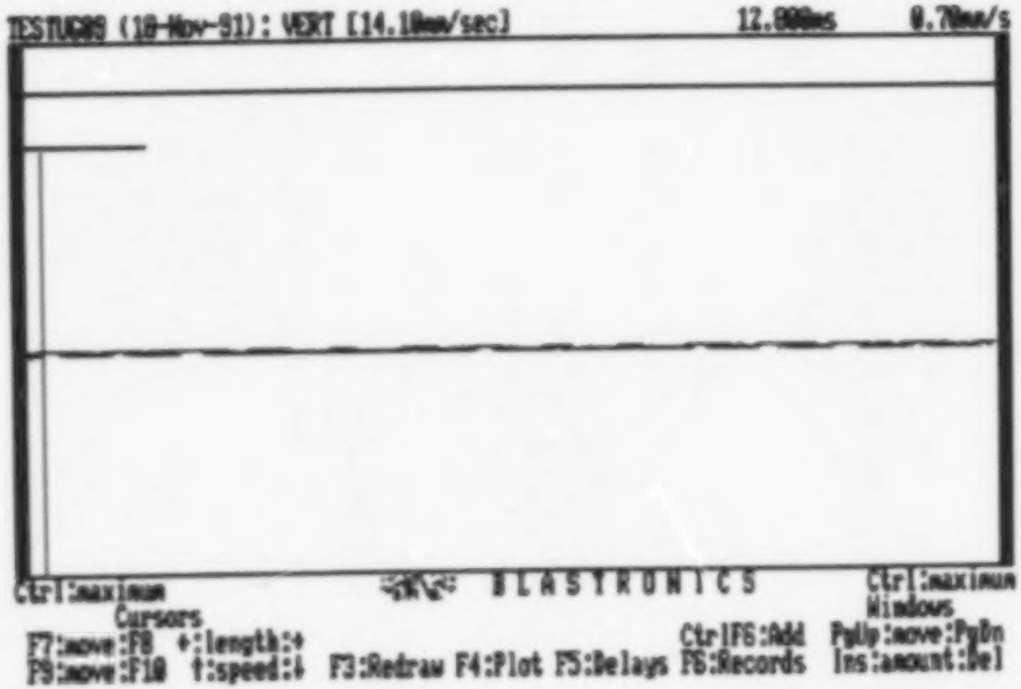

TESTUG08 (18-Nov-91): VERT [14.18mm/sec]
284.700ms
0.70mm/s
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
BLASTRONICS
F3:Redraw F4:Plot F5:Delays
Ctrl F6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

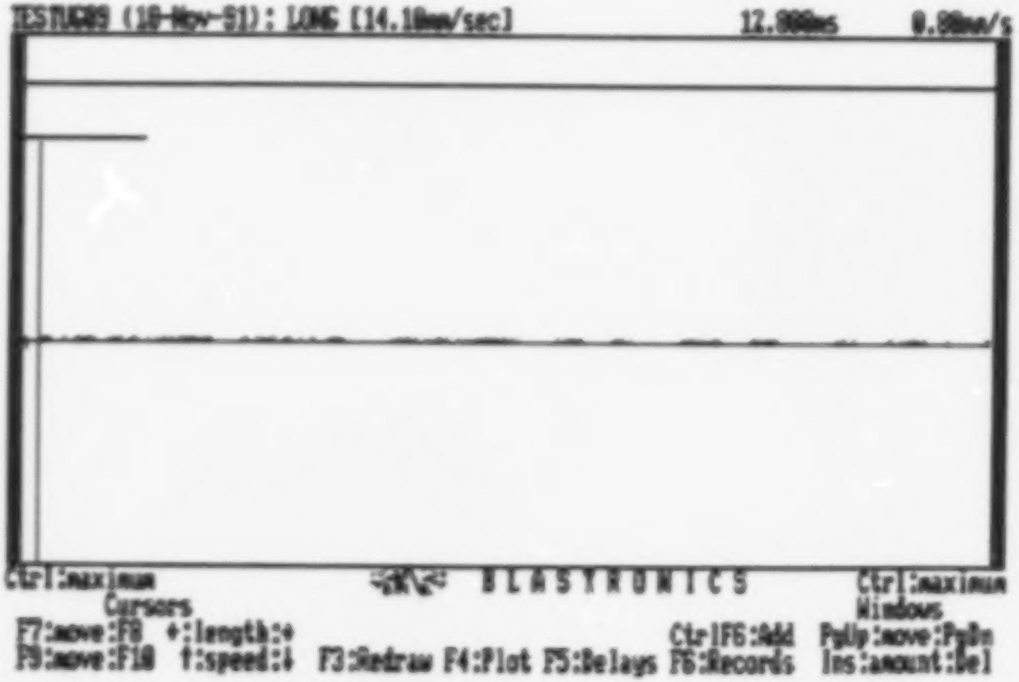


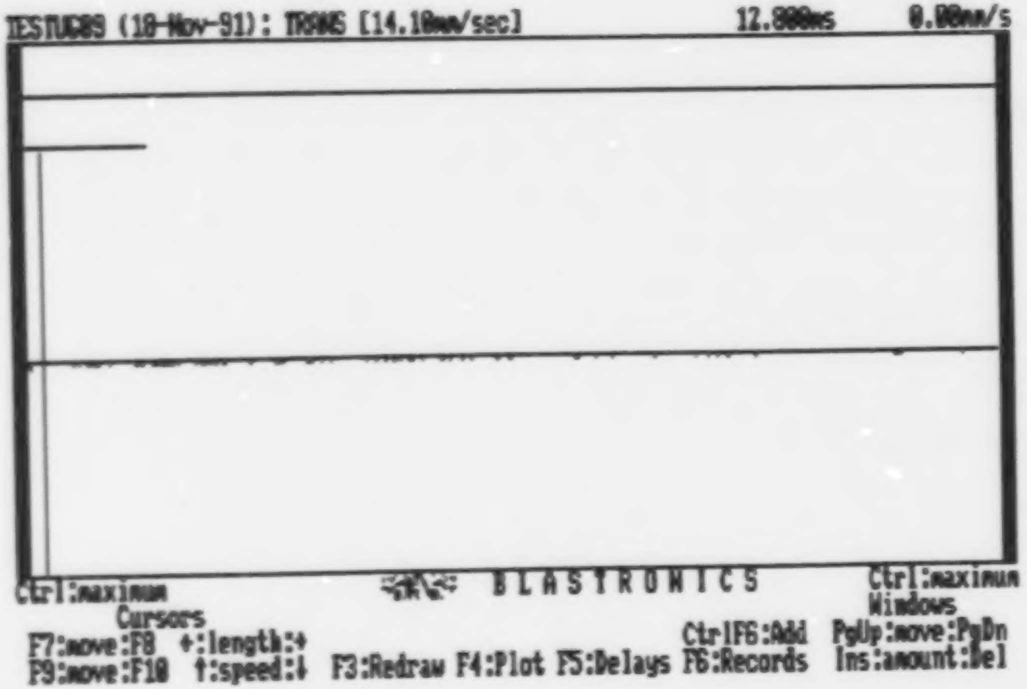
```
TESTUG08 (18-Nov-91): LONG [14.10mm/sec]          284.700ms     0.70mm/s
```

Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
BLASTRONICS
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

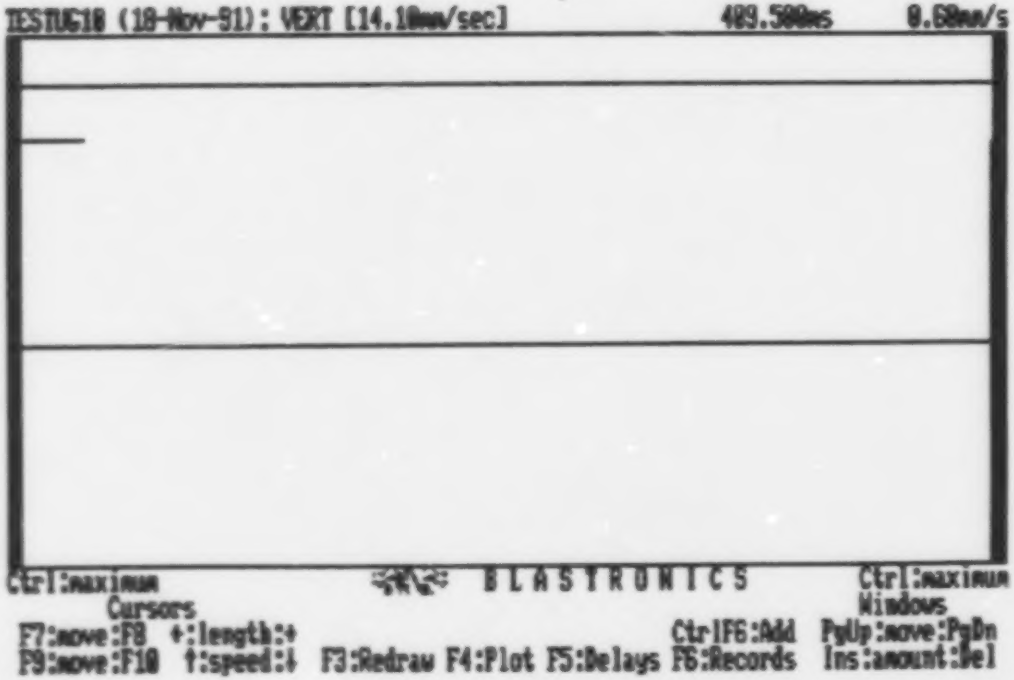

TESTUG08 (18-Nov-91): TRANS [14.10mm/sec]
204.700ms
0.10mm/s
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
BLASTRONICS
F3:Redraw F4:Plot F5:Delays
Ctrl F6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del


TESTUG09 (10-Nov-91): VERT [14.10mm/sec]
12.800ms
0.70mm/s
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
BLASTRONICS
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del


TESTUG09 (18-Nov-91): LONG [14.10mm/sec]
12.000ms
0.00mm/s
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
BLASTRONICS
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del

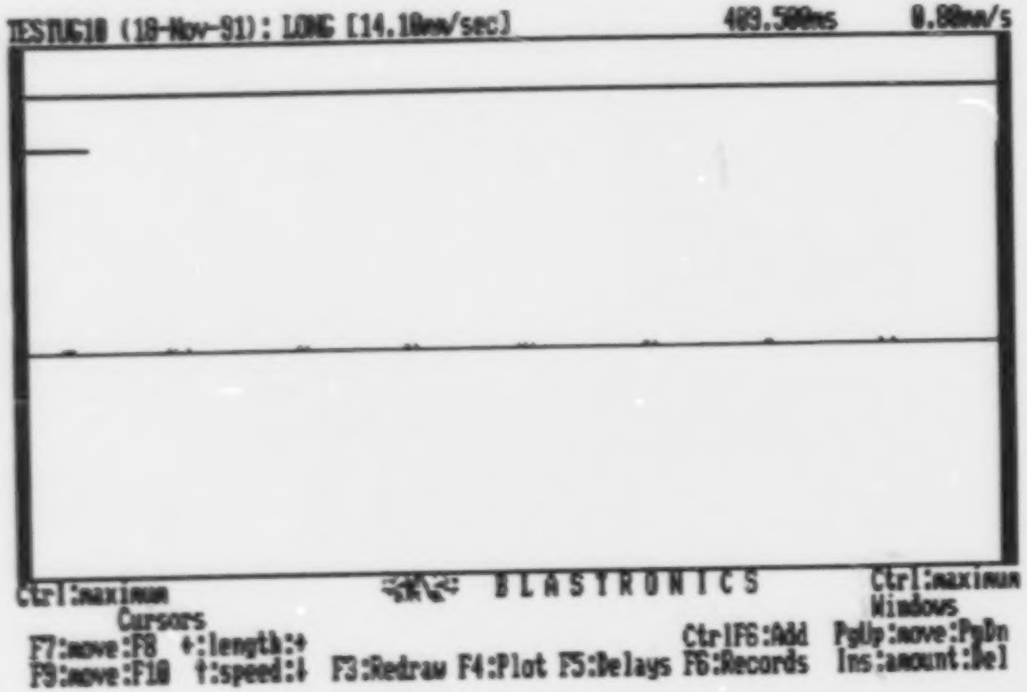


```
TESTUG09 (18-Nov-91): TRANS [14.10mm/sec]          12.800ms     0.00mm/s
Ctrl:maximum                      B L A S T R O N I C S            Ctrl:maximum
     Cursors                                                       Windows
F7:move:F8  +:length:+                                  CtrlF6:Add  PgUp:move:PgDn
F9:move:F10  ↑:speed:↓  F3:Redraw F4:Plot F5:Delays F6:Records  Ins:amount:Del
```



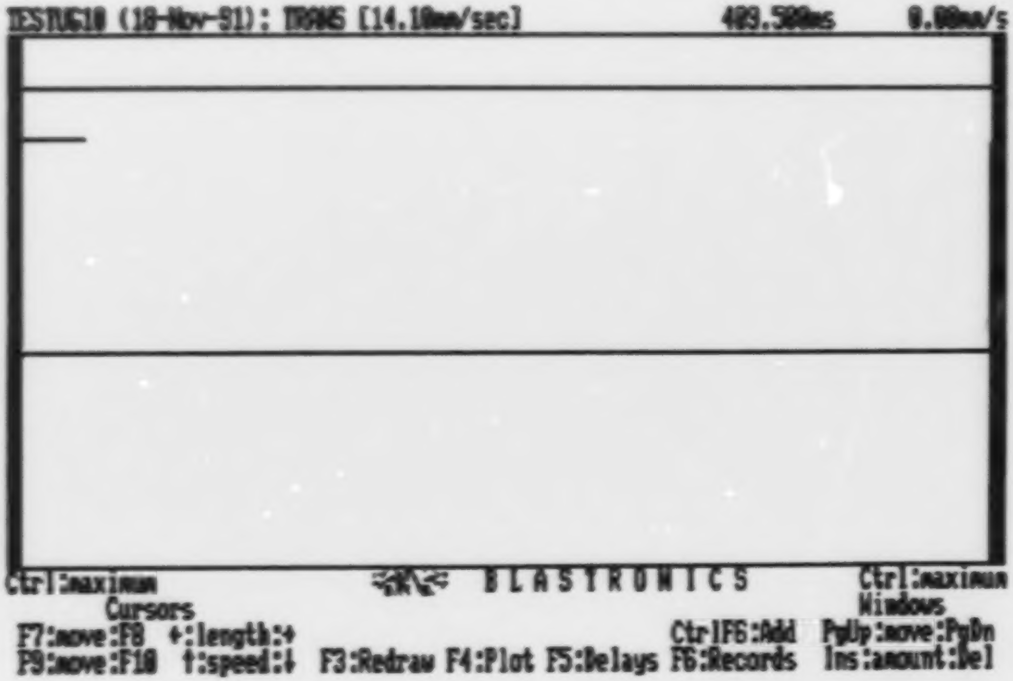
```
TESTUG10 (18-Nov-91): VERT [14.10mm/sec]          409.500ms     0.60mm/s
```

Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
BLASTRONICS
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del



TESTUG10 (18-Nov-91): LONG [14.10mm/sec] 403.500ms 0.00mm/s

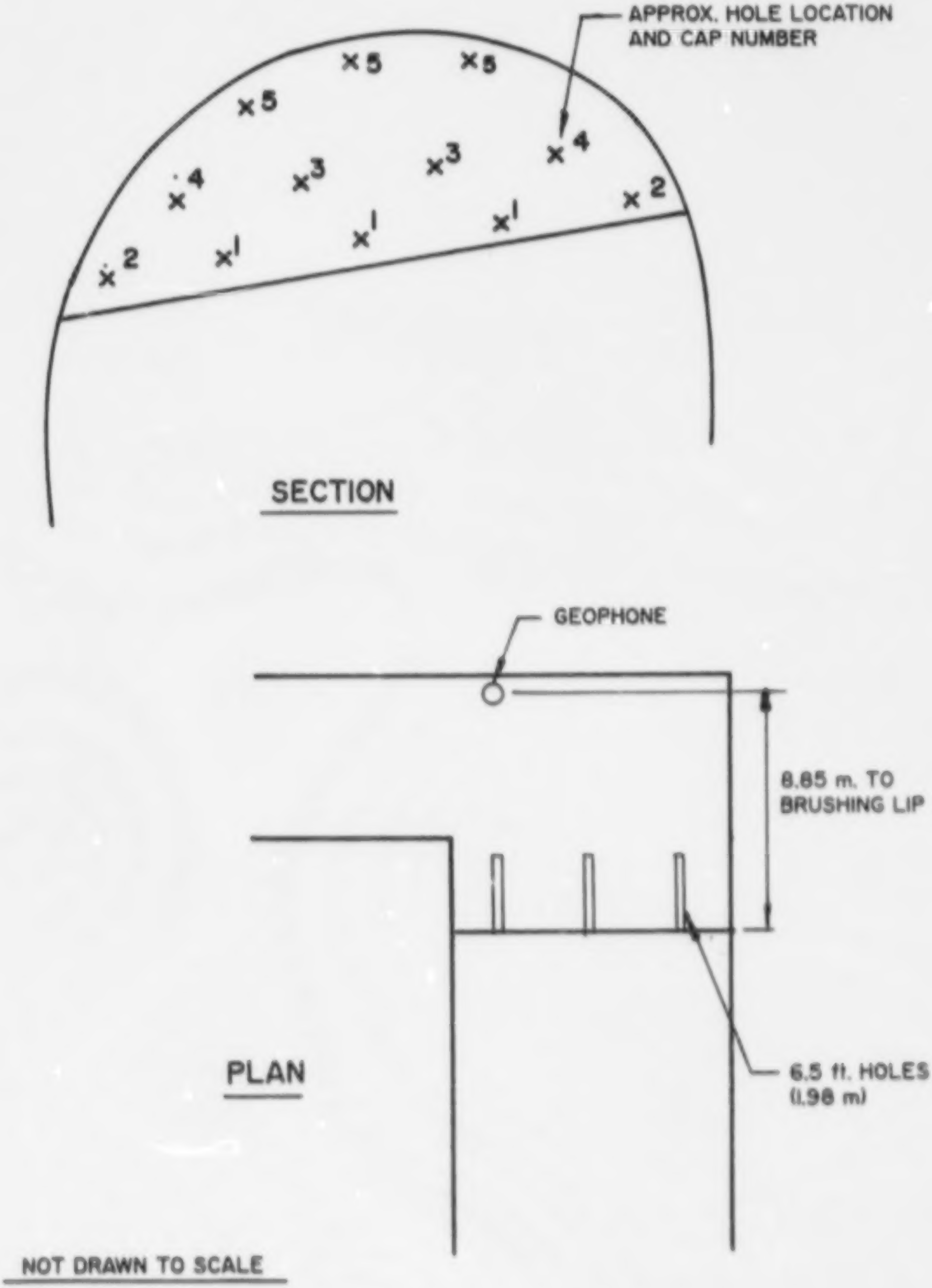
BLASTRONICS
Ctrl:maximum
Cursors
F7:move:F8 ←:length:→
F9:move:F10 ↑:speed:↓
F3:Redraw F4:Plot F5:Delays
CtrlF6:Add
F6:Records
Ctrl:maximum
Windows
PgUp:move:PgDn
Ins:amount:Del



```
TESTUG10 (18-Nov-91): TRANS [14.10mm/sec]                403.500ms     0.00mm/s
Ctrl:maximum                  BLASTRONICS                     Ctrl:maximum
        Cursors                                               Windows
 F7:move:F8  ←:length:→                           CtrlF6:Add  PgUp:move:PgDn
 F9:move:F10  ↑:speed:↓  F3:Redraw F4:Plot F5:Delays F6:Records  Ins:amount:Del
```

Lingan Colliery: Blast Layout Sketch
Blast # LING03

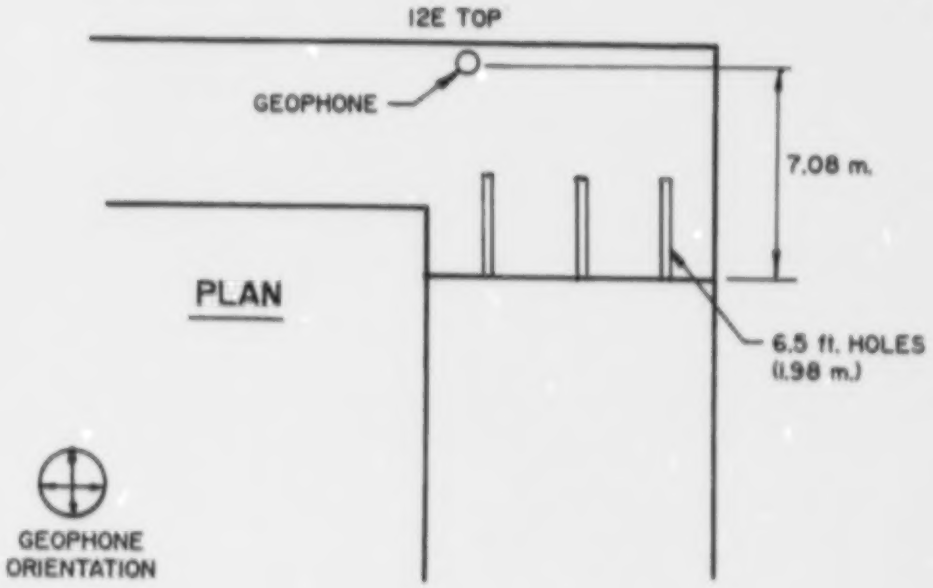
Figure E1


APPROX. HOLE LOCATION AND CAP NUMBER
5
5
5
4
3
3
4
2
2
1
1
1
SECTION
GEOPHONE
8.85 m. TO BRUSHING LIP
PLAN
6.5 ft. HOLES (1.98 m)
NOT DRAWN TO SCALE

Lingan Colliery: Blast Layout Sketch
Blast # LING05

Figure E2

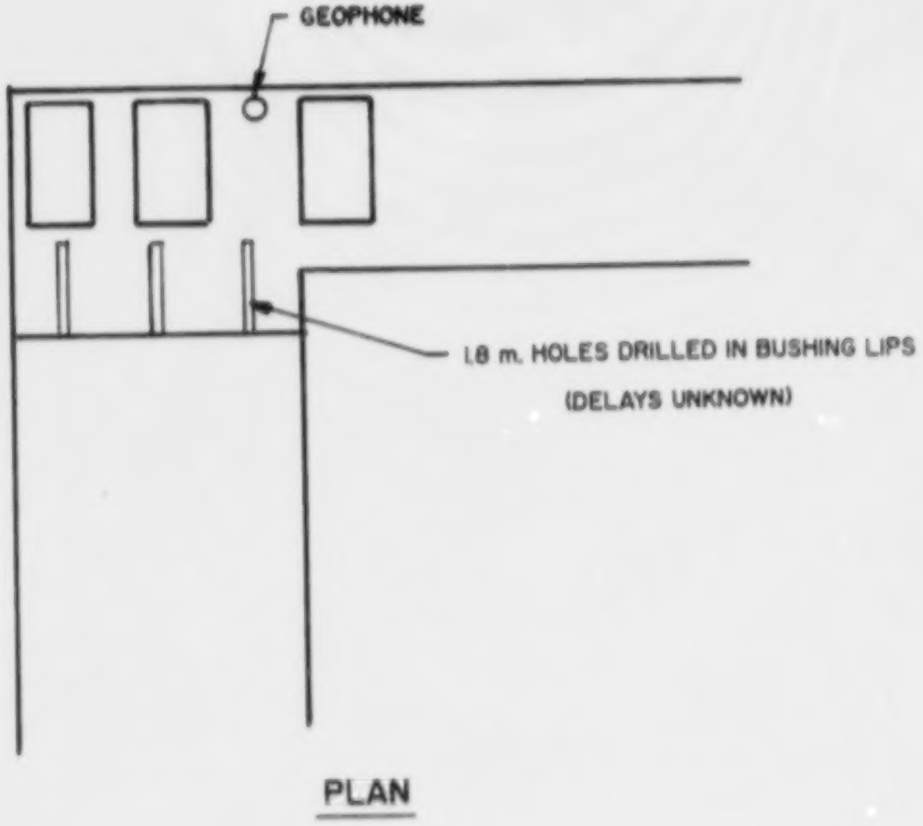
NOTE : HOLE LOCATIONS AND SEQUENCING AS IN FIGURE E I


12E TOP
GEOPHONE
7.08 m.
PLAN
6.5 ft. HOLES
(1.98 m.)
GEOPHONE
ORIENTATION

NOT DRAWN TO SCALE

Lingan Colliery: Blast Layout Sketch
Blast # LING06

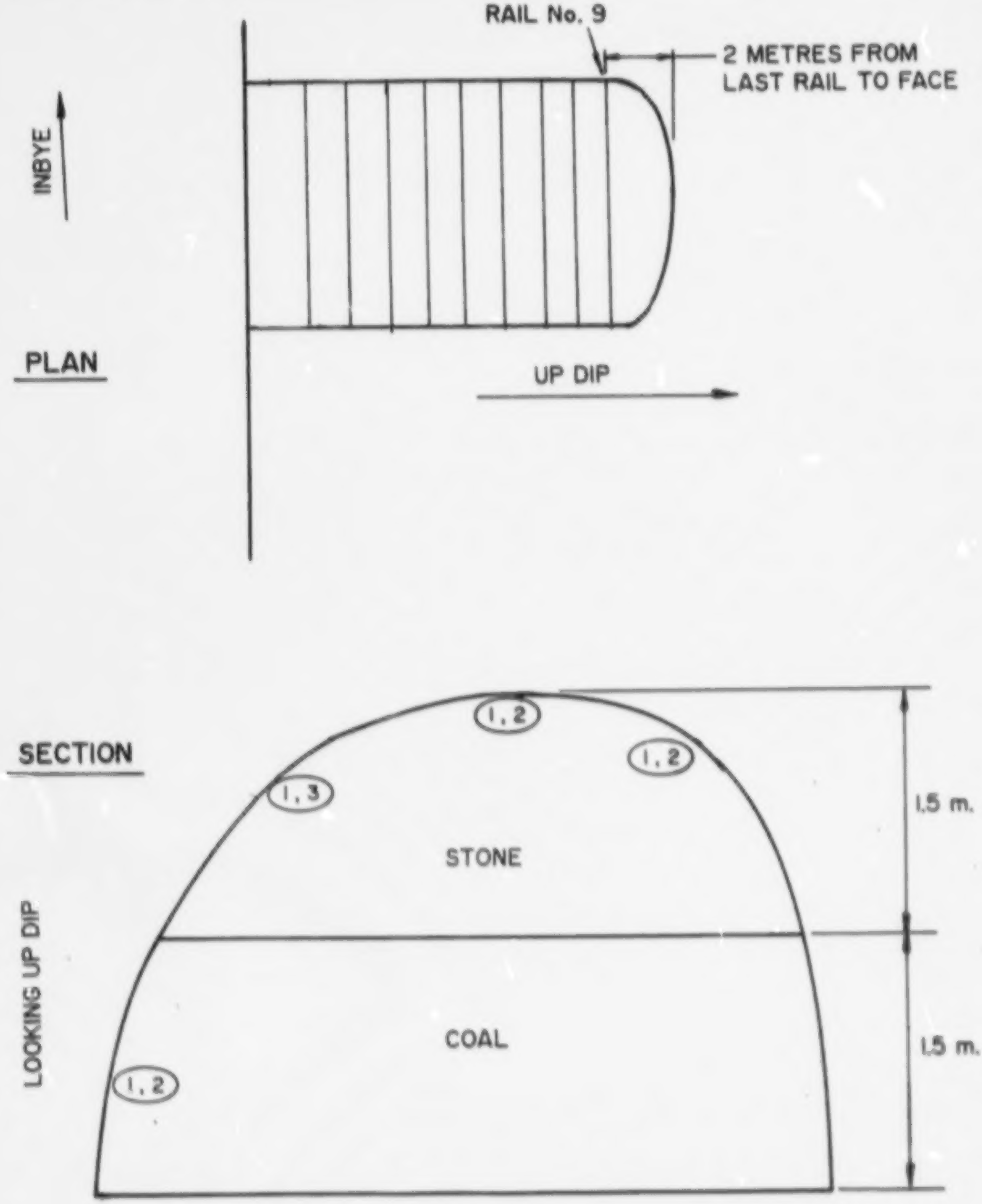
Figure E3


GEOPHONE
1.8 m. HOLES DRILLED IN BUSHING LIPS
(DELAYS UNKNOWN)
PLAN

NOT DRAWN TO SCALE

Lingan Colliery: Blast Layout Sketch
Blast # 13EB2

Figure E4

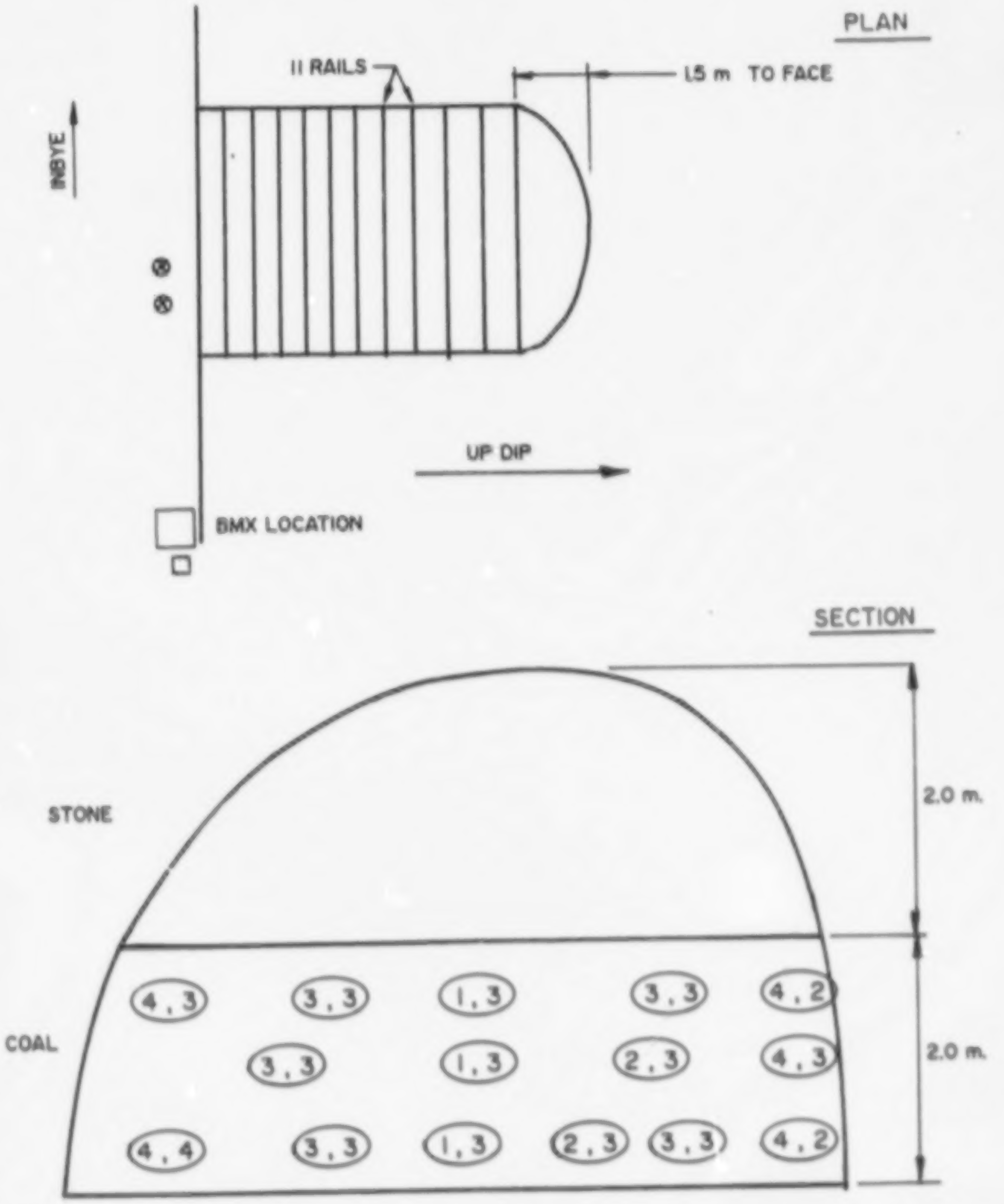

RAIL No. 9
2 METRES FROM LAST RAIL TO FACE
INBYE
PLAN
UP DIP
SECTION
1,2
1,2
1,3
STONE
1.5 m.
LOOKING UP DIP
COAL
1,2
1.5 m.

(1, 2) = No. I CAP , 2 STICKS OF 500 GRAMS OF POWDER

NOT DRAWN TO SCALE

Lingan Colliery: Blast Layout Sketch
Blast # 13EB3

Figure E5


PLAN
II RAILS
1.5 m TO FACE
INBYE
UP DIP
BMX LOCATION
SECTION
STONE
COAL
2.0 m.
2.0 m.
4 , 3
3 , 3
1 , 3
3 , 3
4 , 2
3 , 3
1 , 3
2 , 3
4 , 3
4 , 4
3 , 3
1 , 3
2 , 3
3 , 3
4 , 2

(1 , 3) = No. 1 CAP , 3 STICKS OF 500 GRAMS OF POWDER

NOT DRAWN TO SCALE

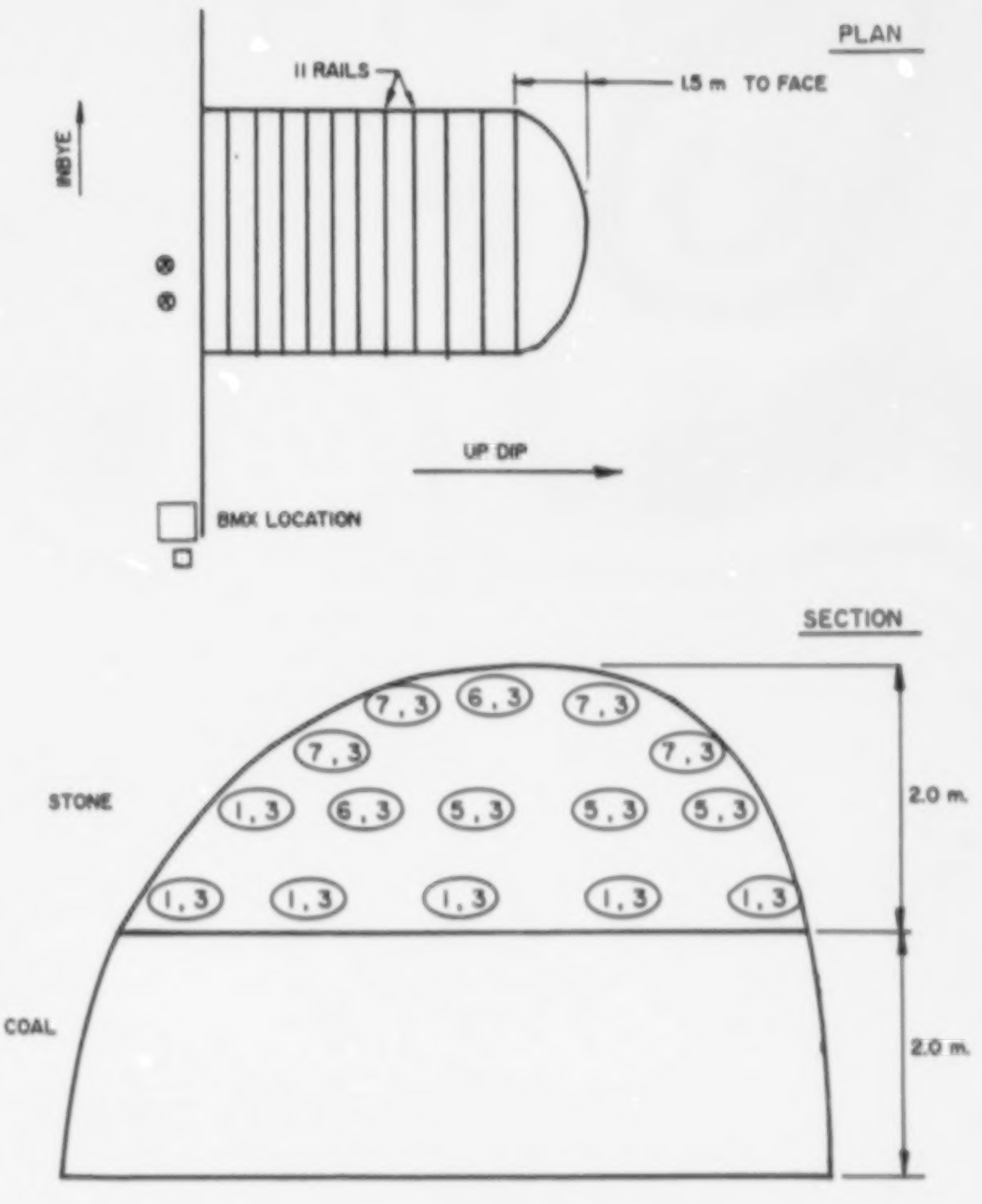
Golder Associates

March 1993

911-1732

Lingan Colliery: Blast Layout Sketch
Blast # 13EB4

Figure E6


PLAN
11 RAILS
1.5 m TO FACE
INBYE
UP DIP
BMX LOCATION
SECTION
STONE
COAL
2.0 m.
2.0 m.
7,3
6,3
7,3
7,3
7,3
1,3
6,3
5,3
5,3
5,3
1,3
1,3
1,3
1,3
1,3

(1,3) = No. 1 CAP, 3 STICKS OF 500 GRAMS OF POWDER

NOT DRAWN TO SCALE

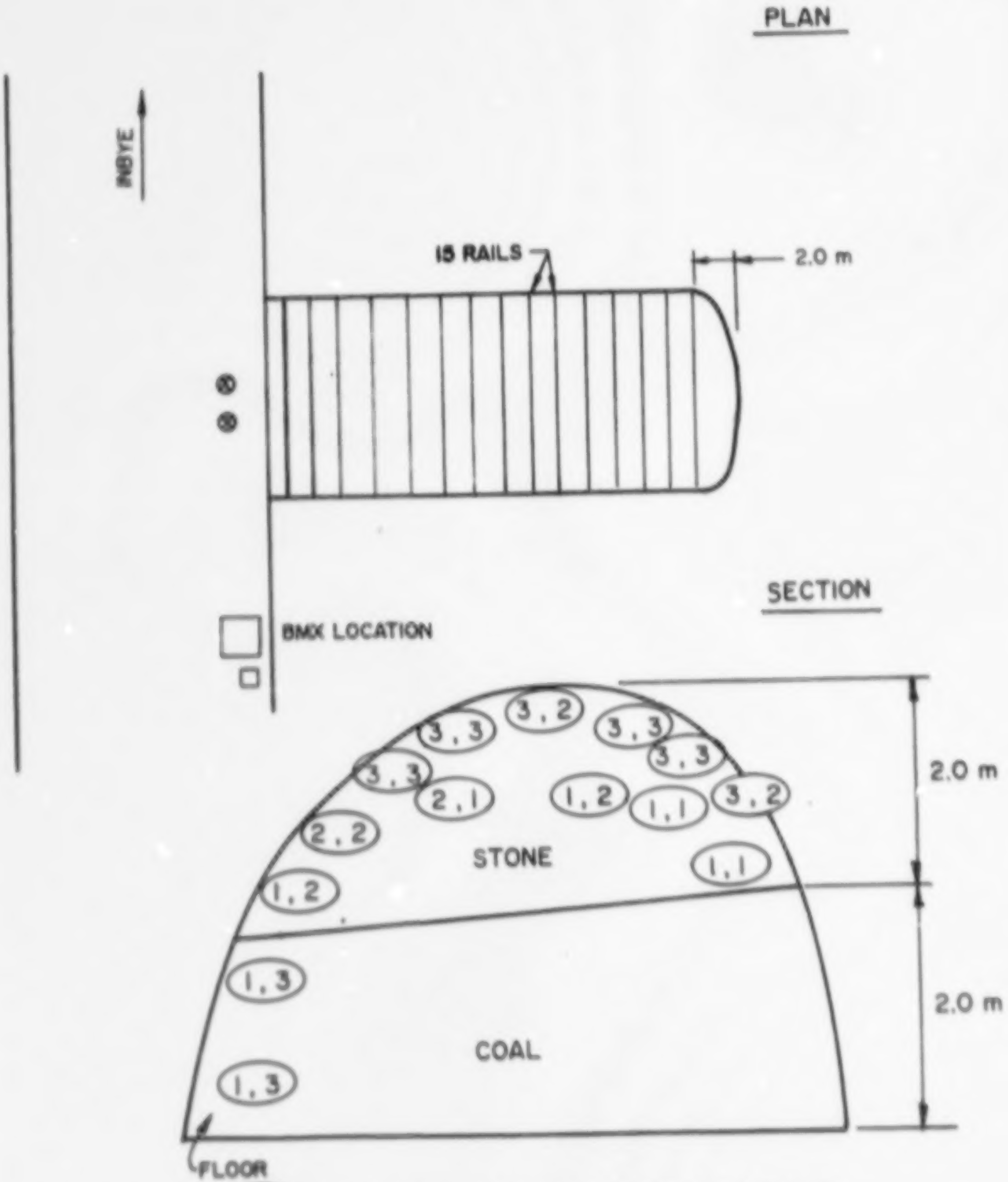
Golder Associates

March 1992

911-1733

Lingan Colliery: Blast Layout Sketch
Blast # 13EB5

Figure E7

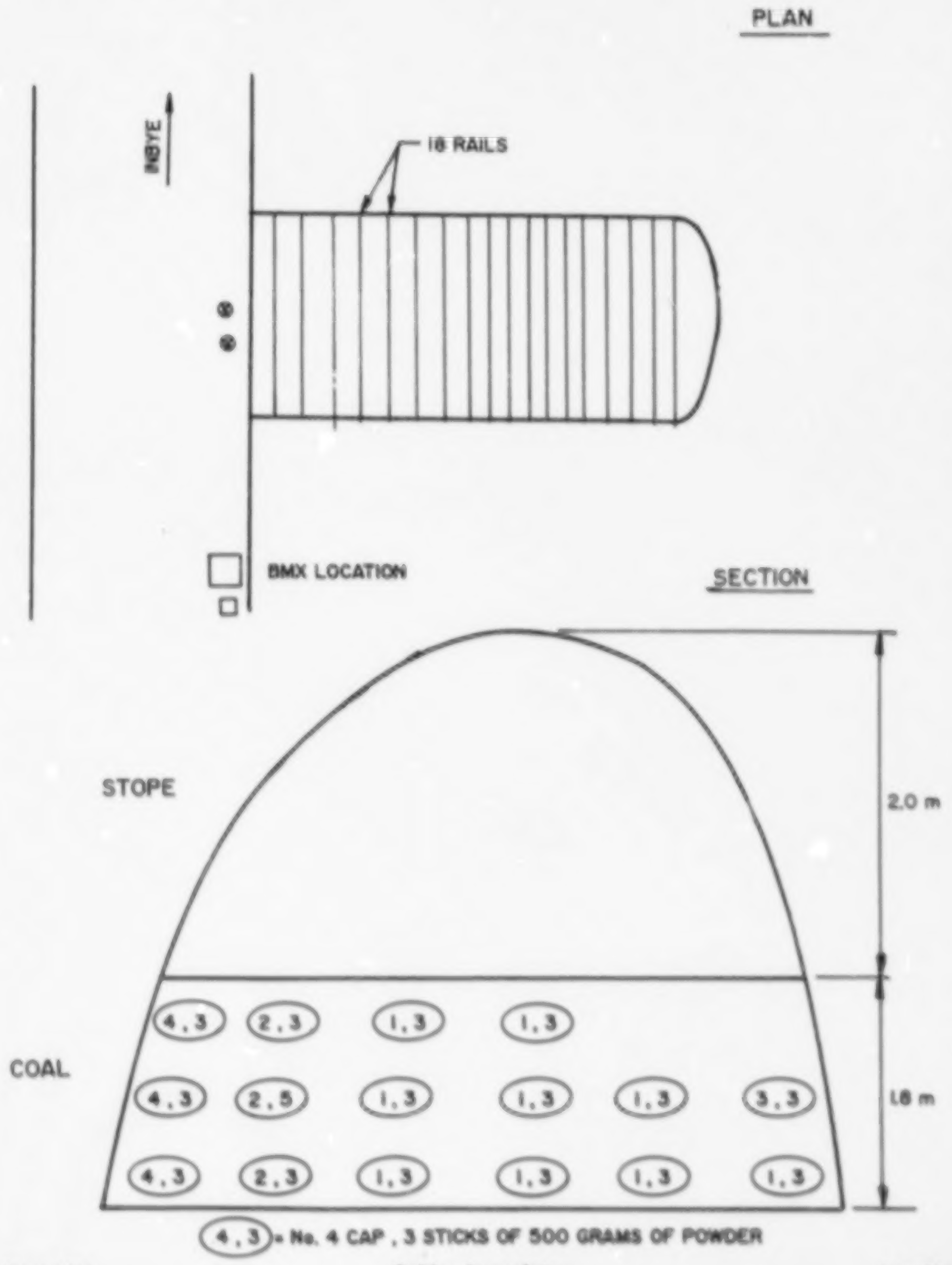

PLAN
INBYE
15 RAILS
2.0 m
BMX LOCATION
SECTION
3, 2
3, 3
3, 3
3, 3
3, 3
2, 1
1, 2
1, 1
3, 2
2, 2
STONE
1, 1
1, 2
2.0 m
1, 3
2.0 m
COAL
1, 3
FLOOR

(1, 3) = No. 1 CAP, 3 STICKS OF 500 GRAMS OF POWDER

NOT DRAWN TO SCALE

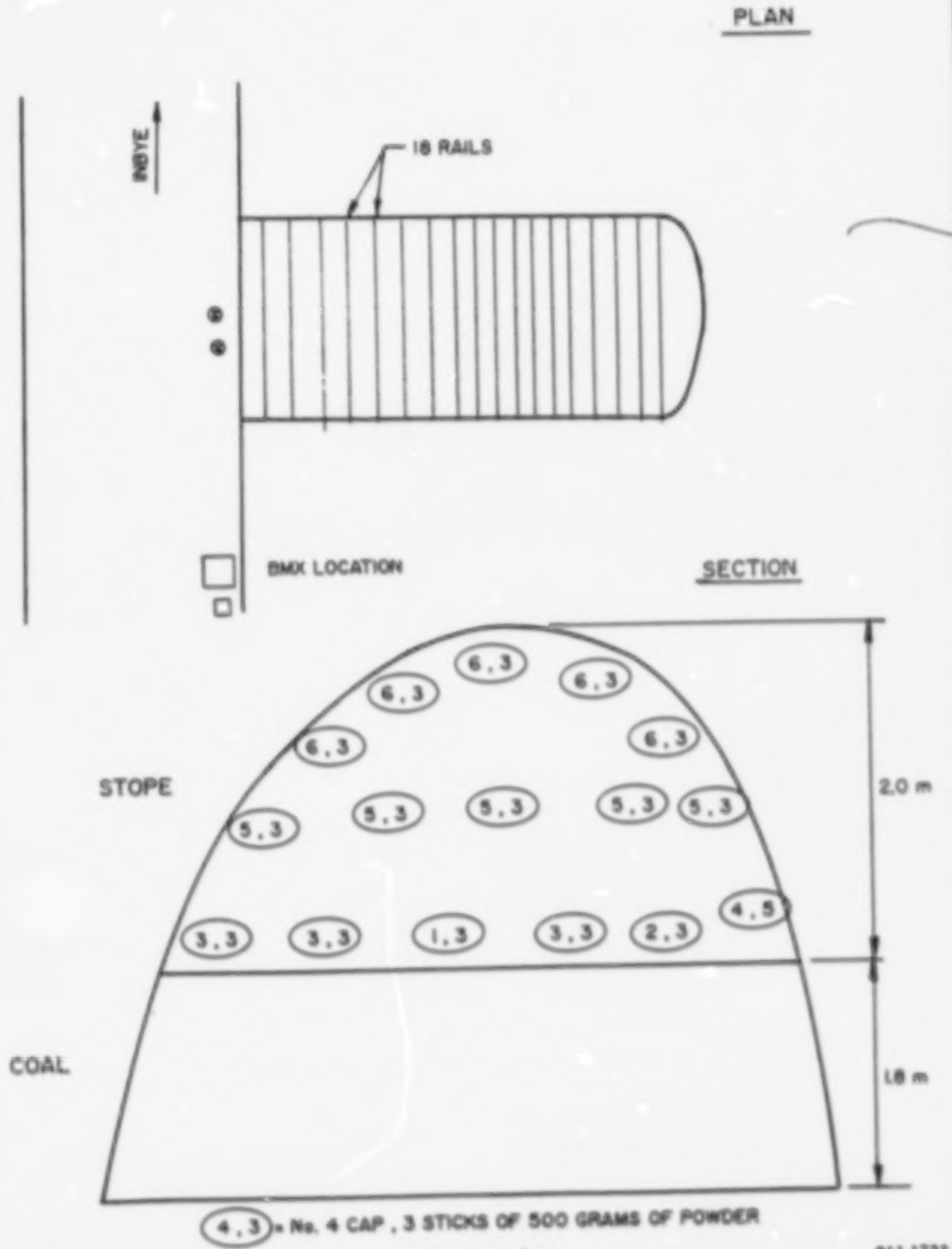
Lingan Colliery: Blast Layout Sketch
Blast # 13EB6

Figure E8


PLAN
INBYE
18 RAILS
BMX LOCATION
SECTION
STOPE
COAL
2.0 m
1.8 m
4, 3
2, 3
1, 3
1, 3
4, 3
2, 5
1, 3
1, 3
1, 3
3, 3
4, 3
2, 3
1, 3
1, 3
1, 3
1, 3
4, 3 = No. 4 CAP, 3 STICKS OF 500 GRAMS OF POWDER

Lingan Colliery: Blast Layout Sketch
Blast # 13EB7

Figure E9


PLAN
INBYE
18 RAILS
BMX LOCATION
SECTION
6 , 3
6 , 3
6 , 3
6 , 3
6 , 3
STOPE
5 , 3
5 , 3
5 , 3
5 , 3
5 , 3
2.0 m
4 , 5
3 , 3
3 , 3
1 , 3
3 , 3
2 , 3
COAL
1.8 m
4 , 3 = No. 4 CAP , 3 STICKS OF 500 GRAMS OF POWDER

March 1992

Golder Associates

911-1733

APPENDIX F

Exemption Order for use of the RocTest MS-3 and BMX Blast Monitor underground at Lingan

Coal Mining Safety Commission
[illegible] George St.
Sydney, Nova Scotia
B1P 1[illegible]

[illegible]

WHEREAS the Coal Mining Safety Commission has received an application from the Cape Breton Development Corporation, an employer for the purposes of subsection 137.2 of the Canada Labour Code, for exemption from compliance with

"Section 138 of the Coal Mines (CBDC) Occupational Safety and Health Regulations"

"All electrical equipment that is used underground shall be intrinsically safe or shall be flameproof"

in the operation of coal mines controlled by it;

AND WHEREAS the Commission is of the opinion that the protection of the safety and health of employees would not be diminished if the exemption were granted;

THE COMMISSION, pursuant to paragraph 137.2(3)(a) of the Canada Labour Code, hereby makes an order exempting the Cape Breton Development Corporation from compliance with Section 138 of the Coal Mines (CBDC) Occupational Safety and Health Regulations, in the operation of coal mines controlled by it subject to the following conditions:

(i) this exemption shall apply to the following electrical equipment only:

Name of Equipment: JK Tech Blastronics
BMX Blast Monitor

Manufacturer: JK Tech
JKMRC Commercial Division
Isles Road
Indooroopilly
Queensland, Australia
4068

(ii) the instrument shall be used only by a person, appointed in writing by the Mine Manager,

(iii) no part shall be changed or repaired underground,

(iv) tests for flammable gas shall be made at regular intervals before and during the use of the instrument,

/2

(v) a record of the time and the result of each test for flammable gas shall be made in writing.

(vi) if any test for flammable gas shows more than 0.5%, use of the equipment shall cease until two consecutive tests at intervals of not less than 5 minutes each show not more than 0.25% flammable gas.

(vii) a written report on the condition of the instrument shall be made at the end of each shift that it is in use.

(viii) this exemption shall come into force: 5th August 1991.

(ix) this exemption shall expire: 4th August 1993.

MADE AT the "Coal Mining Safety Commission Office", 308 George Street, Sydney, Nova Scotia, B1P 1J8, THIS 2nd August 1991.

CHAIRMAN: A.D. Oliver
A.D. Oliver

Tel: (902) 564-7130 [illegible]

Coal Mining Safety Commission
308 George St.
Sydney, Nova Scotia
B1P 1J8

ORDER 91-6 EXEMPTION

WHEREAS the Coal Mining Safety Commission has received an application from the Cape Breton Development Corporation, an employer for the purposes of subsection 137.2 of the Canada Labour Code, for exemption from compliance with

"Section 138 of the Coal Mines (CBDC) Occupational Safety and Health Regulations"

"All electrical equipment that is used underground shall be intrinsically safe or shall be flameproof"

in the operation of coal mines controlled by it;

AND WHEREAS the Commission is of the opinion that the protection of the safety and health of employees would not be diminished if the exemption were granted;

THE COMMISSION, pursuant to paragraph 137.2(3)(a) of the Canada Labour Code, hereby makes an order exempting the Cape Breton Development Corporation from compliance with Section 138 of the Coal Mines (CBDC) Occupational Safety and Health Regulations, in the operation of coal mines controlled by it subject to the following conditions:

(i) this exemption shall apply to the following electrical equipment only:

Name of Equipment:	SINCO Geo-Monitor Model MS-3 53311
Manufacturer:	SINCO Slope Indicator Co. 3668 Albion Place N. P.O. Box C-30316, Seattle WA. 98103 U.S.A.

(ii) the instrument shall be used only by a person, appointed in writing by the Mine Manager.

(iii) no part shall be changed or repaired underground.

(iv) tests for flammable gas shall be made at regular intervals before and during the use of the instrument.

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[illegible] of 20

(v) a record of the time and the result of each test for flammable gas shall be made in writing.

(vi) If any test for flammable gas shows more than 0.5%, use of the equipment shall cease until two consecutive tests at intervals of not less that 5 minutes each show not more than 0.25% flammable gas.

(vii) a written report on the condition of the instrument shall be made at the end of each shift that it is in use.

(viii) this exemption shall come into force: `5th August 1991.`

(ix) this exemption shall expire: `4th August 1993.`

MADE AT the "Coal Mining Safety Commission Office", 308 George Street, Sydney, Nova Scotia, B1P 1J8, THIS 2nd August 1991.

CHAIRMAN: A.D. Oliver
A.D. Oliver

APPENDIX G

Shotfiring procedures for use when advancing through a sandstone channel

CAPE BRETON
DEVELOPMENT
CORPORATION

SOCIÉTÉ DE
DÉVELOPPEMENT
DU CAP-BRETON

1990 November 15

THE COAL MINING SAFETY COMMISSION
308 GEORGE STREET
SYDNEY, NOVA SCOTIA
B1P 1J8

ATTENTION: MR. T.E. SMALES

Dear Mr. Smales:

Further to the discussions that were held with the Coal Mines Safety Commission on November 14, 1990, we are submitting this proposal for approval under Section 158 (1) of the Coal Mines (CBDC) Occupational Safety and Health Regulations.

INTRODUCTION

Since Lingan Mine is now operating at depths where outbursts of rock and gas (similar to those encountered in No. 26 Colliery) are possible, it is proposed that exploratory drilling be carried out in advance of the working face in 13 East Bottom Level. The purpose of this drilling is to locate sandstone bodies in the roof strata and examine the drill core for "discing". Discing is generally recognized as a primary indicator of outburst-prone ground.

Sandstone identified during drilling will be subjected to shotfiring when it enters the working face to verify that the rock is or is not outburst prone. Following are the procedures proposed for carrying out these activities.

DRILLING

1. Boreholes will be drilled on weekends when the heading is not working.

2. The borehole will be collared in the stone face above the coal and inclined at an angle which will find the borehole about 3 m above the roof of the coal seam at the borehole termination point. The general arrangement of drilling is shown on attached Drawing 13EG1.

.../2

Canada

P.O. Box 2500, Sydney, N.S., Canada B1P 6K9 Telephone (902) 564-2848, Telex 019-351-32
C.P. 2500, Sydney, N.É. Canada B1P 6K9 Telephone (902) 564-2848, Telex 019-351-32

3. Five feet of casing will be installed and sealed with denso tape, rubber sealer or other suitable sealant.

4. Drilling will be carried out using the Corporation's air powered Longyear 65 drill (previous approval #90-31) or other similar approved drill.

5. The borehole will be filled upon completion.

6. Only qualified drilling personnel will be used.

7. A qualified person will be at the site during drilling to monitor for gas and general conditions of safety.

SHOTFIRING

In the event that sandstone is encountered during drilling, the following procedure will be followed:

1. The coal seam will be removed prior to shooting the stone face.

2. If the cored sandstone does not exhibit discing, it nonetheless be drilled and shot upon first being encountered on the working face to test for outburst tendency.

3. If the cored sandstone does exhibit discing, it shall be bored and shot upon first being encountered at the working face. If outburst activity results from this shot, all subsequent advance through the sandstone will be carried out using shotfiring. If no evidence of outburst activity is observed, shotfiring will be carried out once a week, or more frequently if required, until the sandstone leaves the face.

4. In the event that an unpredicted sandstone enters the face, it shall be bored and shot as soon as possible to test for outburst activity and subsequent actions will be the same as (2) and (3) above.

5. All shotfiring will be carried out in accordance with the Coal Mines (CBDC) Occupational Safety and Health Regulations.

.../3

I trust you will find these procedures satisfactory.

Yours truly,

R. McIntyre
Colliery General Manager
Lingan Colliery

:dc

cc: R. Cooper
S. Forgeron
Z. Fuginski
J. Kochhar
R. MacLean
J. Shea
O.H.S. Committee

CAPE BRETON
DEVELOPMENT
CORPORATION

SOCIÉTÉ DE
DÉVELOPPEMENT
DU CAP-BRETON

1990-11-23

THE COAL MINING SAFETY COMMISSION
308 GEORGE STREET
SYDNEY, NOVA SCOTIA
B1P 1J8

ATTENTION: MR. TOM SMALES

SUBJECT: SHOTFIRING PROCEDURE FOR 13 EAST BOTTOM

Dear Sir:

Further to discussion held during the meeting of the Safety Commission on November 22, 1990, please find attached the shotfiring plan and procedure **(DRAWING 1057-E)** we propose to use on 13 East Bottom Level at Lingan Colliery.

This shot will be used to determine whether or not the sandstone is prone to outbursts.

Yours truly,

Reg Mac

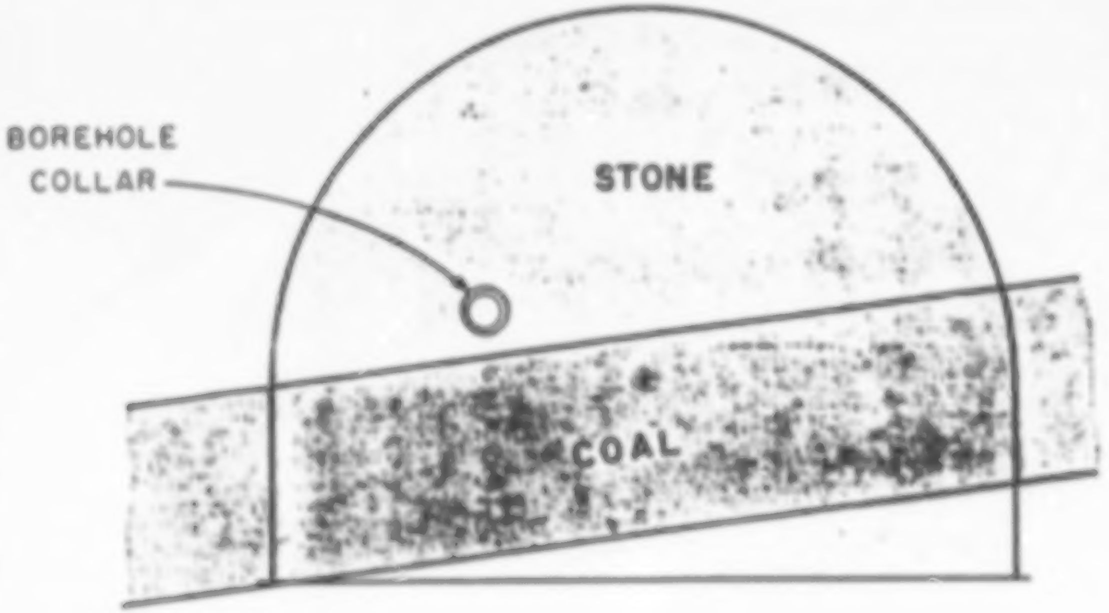
Reg MacIntyre
General Manager
Lingan Colliery

c.c. R. MacLean
B. Cooper
E. Fuginski ✓
S. Forgeron
O.H.S. Committee

Enclosure

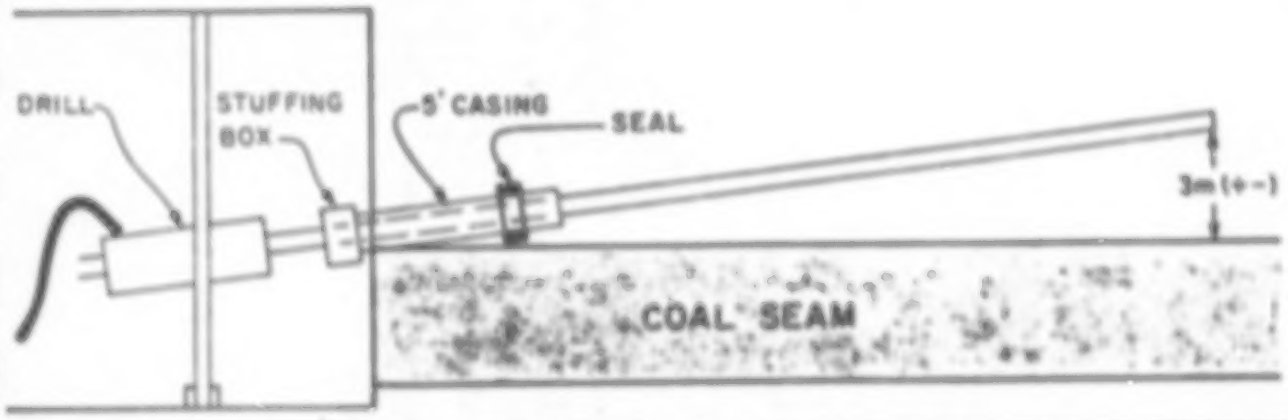
:acm

Canada


BOREHOLE COLLAR
STONE
COAL

SCHEMATIC DRAWING OF FACE SHOWING COLLAR LOCATION OF BOREHOLE.

PROFILE SHOWING GENERAL ARRANGEMENT OF DRILLING.


DRILL
STUFFING BOX
5' CASING
SEAL
3m (+-)
COAL SEAM

CAPE BRETON DEVELOPMENT CORPORATION

Location: LINGAN COLLIERY
Title: 13 EAST BOTTOM LEVEL PROPOSED BOREHOLE DRILLING.
Drawn By: K. A. G.
Chkd. By:

Dwg. No. 13 EG 1

CAPE BRETON
DEVELOPMENT
CORPORATION

SOCIÉTÉ DE
DÉVELOPPEMENT
DU CAP-BRETON

1990 December 06

The Coal Mining Safety Commission
308 George Street
Sydney, Nova Scotia
B1P 1J9

ATTENTION: T.E. SMALES

Dear Mr. Smales:

This letter is written to formally address the discussions held in your office on December 4, 1990 with respect to probe drilling on 13 East Bottom Level at Lingan. Further to those discussions, we are submitting this proposal for approval under Section 158 (1) of the Coal Mines (CBDC) Occupational Safety & Health Regulations.

PREAMBLE

Please refer to Drawing No. LIN13E-3; it forms an integral part of this proposal. This drawing is a partial plan of Lingan Colliery upon which sandstone bodies (mapped by CBDC Geological staff) are plotted in plan view. The lateral limits shown represent where these bodies can be seen in the mine workings. The actual width of these bodies extend beyond the limits shown as one moves upward into the roof.

Based on our interpretation of geological evidence, the location of these sandstone bodies is projected into the unmined coal blocks ahead of the workings. This is done, of course, to allow us to prepare plans to handle the negative effects of sandstone strata on mining operations. These projections represent our best estimate of where the channels will occur in the future. The accuracy of the projections decreases with increasing distance from the nearest control point. This is expected because of the fickle nature of river depositional processes.

On Drawing No. LIN13E-3, you will note that five sandstone bodies have been projected to intersect 13 East Bottom Level. These channels are labelled A, B, C, D, and E. You will also note that this level occurs below the -2300 mining depth. Below this depth, in No. 26 Colliery, rock and gas outbursts

..../2

Canada

occurred while advancing development roadways through sandstone strata using shotfiring mining methods.

Fortunately, no outbursts have occurred to date at Lingan, nor have any been experienced elsewhere, at equally deep collieries, in the Sydney Coalfield.

Fully realizing the special nature of outbursts, but also being cognisant of the fact that they can be extremely hazardous to mining, we have adopted the policy at Lingan, that all sandstone bodies below a depth of 2300 below sea level will be treated as potential outburst risks.

To this end, we have been drilling ahead of the slopes and, more recently, ahead of 13 East Bottom Level to locate projected sandstone bodies in order to evaluate their outburst potential. Core discing in the sandstone is the indicator we have adopted to identify outburst-prone ground.

RECENT WORK ON 13 EAST BOTTOM LEVEL

The first sandstone body (Body A) was projected to cross the path of the 13 East Bottom Level about 3 weeks ago. At that time, a series of upholes (+65°) and forward probe holes (+5°) to test for this sandstone ahead of the working face, were drilled. The location of these boreholes are shown on Drawing No. LIN13E-3. No significant sandstone was encountered in the forward probe holes (13E-2, 13E-4 and 13E-5), suggesting that sandstone Body A was not present. The upholes did, however, intersect a sandstone bed which exhibited core discing. Upholes 13E-1, 13E-3 and 13E-4A cut 4.2', 7' and 5' of sandstone respectively about 23' above the seam. These thicknesses suggest that a channel-form deposit of sandstone is present, with the thickest section, (7') in borehole 13E-3, representing the channel centre. Since this channel lies approximately where Sandstone Body A was projected to occur, it is not unreasonable to assume that it is Sandstone A and has risen upward into the roof in relation to its location on 12E Bottom Level.

Our interpretation of current information is that we have passed through the influence of Sandstone Body A. The next sandstone body (B) is expected to intersect the level about 450' from the December 1 surveyed location of the face.

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PROPOSAL

It is proposed that forward probe drilling be discontinued until 13 East Bottom Level is within 150' of Sandstone Body B. At that time, probe drilling will again begin and continue until we have passed through that body. In regards to sandstone bodies, C, D and E, we propose that forward probe drilling be carried out in the areas coloured orange and discontinued in the areas shaded blue on Drawing No. LIN13E-3.

By way of detail, the procedures outlined below are proposed for outburst monitoring while working in these two zones.

1. WITHIN THE INFLUENCE OF PROJECTED SANDSTONE BODIES
Coloured Orange on Drawing LIN13E-3

When 13 East Bottom Level arrives within the 100 foot influence area of the projected sandstone bodies, we propose to drill forward probe holes ahead of the face on weekends, for a distance sufficient to cover the following week's anticipated advance (120'±). This work will be done in accordance with Approval 90-63. A cored uphole will also be drilled as soon as can be practically done after entering the sandstone influence zone. Additional upholes will be drilled as conditions dictate.

2. BETWEEN PROJECTED LOCATIONS OF SANDSTONE BODIES
Shaded Blue on Drawing LIN13E-3

When driving in the areas between the projected sandstone bodies, we propose that the drilling of forward probe holes be discontinued. Upholes will be drilled, however, at 350 to 400' intervals per Approval 90-31 and more frequently if conditions (found during geological face mapping, bolt hole drilling, etc,) warrant. If an unpredicted sandstone enters the face while working in these inter-sandstone zones, the face will be bored and shot as soon as can be practically done (per Approval 90-64) and we will revert to the drilling procedure proposed in (1) above.

3. OTHER WORK

We propose to drill cored boreholes using our WOMBAT bolt hole drill, along 12 East Bottom Level to study the

....../4

thickness and extent of the sandstone body's mapped there. This work is proposed so we can refine the projections of sandstone bodies on 13 East Bottom Level.

Yours truly,

Reg McIntyre
General Manager
Lingan Colliery

cc: R. MacLean
R. Cooper
Z. Fuginski
S. Forgeron
O.H.S. Comittee

Enclosure